Rules

2021

Rules for the Classification of Steel Ships

Part 7 Ships of Special Service

Guidance

2021

Guidance Relating to the Rules for the Classification of Steel ships

Part 7 Ships of Special Service

2021

Rules for the Classification of Steel Ships

Part 7
Ships of Special Service

RA-07A-E

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APPLICATION OF PART 7 "SHIPS OF SPECIAL SERVICE"

1. Unless expressly specified otherwise, the requirements in these Rules apply to ships for which contracts for construction are signed on or after 1 July 2021.
2. The amendments to the Rules for 2020 edition and their effective date are as follows;

Effective Date : 1 July 2021

CHAPTER 1 OIL TANKERS

Section 2 Hatchways, Gangways and Freeing Arrangements
- 203 has been amended.

Section 10 Piping Systems and Venting Systems for Oil Tankers
- 1001. 4 has been newly added.

CHAPTER 3 BULK CARRIERS

Section 1 General
- 101. 7 has been newly added.

Section 2 Harmonized Notations and Corresponding Design Loading Conditions
- 201. 5 (1) has been amended.

Section 14 Water Level Detection & Alarms and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships
- 1401. has been amended.

CHAPTER 4 CONTAINERS

Section 1 General
- 101. 6 has been newly added.
- 103. has been newly added.

Section 10 Freight Container Securing Arrangements
- 1002. 2 has been amended.
- 1002. 4 has been newly added.

CHAPTER 7 CAR FERRIES AND ROLL-ON/ROLL-OFF SHIPS

Section 1 General
- 101. 2 has been amedned.

CHAPTER 9 TUGS

Section 8 Towing Winch Emergency Release Systems

- Sec.8 has been newly added.

CHAPTER 10 DOUBLE HULL TANKERS

Section 9 Hatchways, Gangways and Freeing Arrangements

- 903. has been amended.

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CHAPTER 1 OIL TANKERS

Section 1 General

101. Application 【See Guidance】

1. The requirements in this Chapter apply to oil tankers which were contracted for construction after 1 April 2006, excluding the vessels which should be applied **Pt 13** (Common Structural Rules for Bulk Carriers and Oil Tankers) and **Ch 10** (Double Hull Tanker). However, **Sec 10** (Piping Systems and Venting Systems for Oil Tankers) and **Sec 11** (Electrical Equipment) apply to oil tankers including the vessels which should be applied **Pt 13** (Common Structural Rules for Bulk Carriers and Oil Tankers) and **Ch 10** (Double Hull Tanker).
2. The construction and equipment of ships intended to be registered and classed as tanker are to be in accordance with the requirements in this Chapter, where a tanker means a ship intended to carry crude oil, petroleum products having a vapour pressure (absolute pressure) less than 0.28 MPa at 37.8℃ or other similar liquid cargoes in bulk.
3. Except where specifically required in this Chapter, the general requirements for steel ships are to be applied.
4. The requirements in this Chapter are framed for tankers with machinery aft, having one or more rows of longitudinal bulkheads, single decks, single bottoms and longitudinal framing.
5. In tankers intended to carry liquid cargoes other than crude oil and petroleum products, having a vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 ℃ and having no hazard as poisonous, corrosive, etc. and moreover less inflammability than that of crude oil and petroleum products, the structural arrangements and scantlings are to be to the satisfaction of the Society, having regard to the properties of the cargoes to be carried.
6. Notwithstanding the each requirement, the application of below requirements may be exempted in accordance with the requirement of flag state.
   (1) **103. 5.**
   (2) **107.**
   (3) **204.**

102. Arrangement of bulkheads 【See Guidance】

In cargo oil tanks, longitudinal and transverse oiltight bulkheads and wash bulkheads are to be arranged suitably.

103. Cofferdams 【See Guidance】

1. Cofferdams of airtight construction and having sufficient width as required for ready access are to be provided at the forward and after ends of cargo oil spaces and between cargo oil spaces and accommodation spaces. In tankers intended to carry oils having a flash point exceeding 60℃, however, the preceding requirements may be modified.
2. The cofferdams described in the preceding Paragraph may be used as pump rooms.
3. Ullage plugs, sighting ports and tank cleaning openings are not to be arranged in enclosed spaces.
4. Fuel oil or ballast water tanks may be concurrently used as the cofferdams to be provided between cargo oil tanks and fuel oil or ballast water tanks, subject to the approval by the Society.
5. Location and separation of spaces in tankers of 500 tons gross and above carrying oils having a flash point not exceeding 60℃ are to be in accordance with the requirements in **Pt 8, Ch 2, 401.**

104. Airtight bulkheads 【See Guidance】

Airtight bulkheads are to be provided for the isolation of all cargo oil pumps and pipings from spaces containing stoves, boilers, propelling machinery, electric installations other than those of ex-

plosion-proof type specified in **Pt 6, Ch 1, Sec 9** or machinery space where source of ignition is normally present. In tankers carrying oils having a flash point exceeding 60℃, however, the preceding requirements may be modified.

105. Ventilation

1. Efficient ventilation is to be provided in spaces adjacent to cargo oil tanks. Air holes are to be cut in every part of the structure where there might be a chance of gases being pocketed.
2. Efficient means are to be provided for clearing oil tanks and pump rooms of dangerous vapours by means of mechanical ventilation or by steam.
3. In tankers carrying oils having a flash point exceeding 60℃ the capacity of ventilation in the pump rooms specified in **1004.** may be modified.
4. The requirements in **1004.** are applied to the ventilation fans and wire mesh screens for the spaces adjacent to the cargo oil tank specified in **Par 1**.

106. Openings for ventilation

Ventilation inlets and outlets are to be arranged so as to minimize the possibilities of vapours of cargoes being admitted to an enclosed space containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard. Especially, openings of ventilation for machinery spaces are to be situated as far afterwards apart from the cargo spaces as practicable.

107. Openings of superstructure and deckhouse

The arrangement of openings on the boundaries of superstructure and deckhouse are to be such as to minimize the possibility of accumulation of vapours of cargoes. Due consideration in this regard is to be given when the ship is equipped to load or unload at the stern. Side scuttles to the poop front or other similar walls are to be of fixed type. Such openings of tankers of 500 tons gross and above carrying oils having a flash point not exceeding 60℃ are to be in accordance with the requirements in **Pt 8, Ch 2, 402.**

108. Thickness of structural members in cargo oil spaces

The thickness of structural members in cargo oil spaces is to be in accordance with the following:

(1) The thickness of shell plating is not to be less than that obtained from the formulae in **Pt 3, Ch 4, 302., 304., 305.** and **404.** using 2.0 in lieu of 1.5 in the formulae.

(2) The thickness of deck plating of freeboard deck is not to be less than that obtained from the formulae in **Pt 3, Ch 5, 301**. using 2.0 in lieu of 1.5 in the formulae.

(3) Where frames, beams, stiffeners and other members for which the scantlings are specified by the section modulus only consist of flanged plates, special sections or web and face plates, the thickness of web plates is not to be less than that obtained from the following formula. Where the depth of web plates, however, is specially made deeper due to the reason from other than strength, the preceding requirements may be modified.

$$t = 0.015 k_0 d_0 + 2.5 \quad (\mathrm{mm})$$

where:

d_0 = depth of web plates (mm)

k_0 = as given in the following formulae. However, value of f_B and f_D is not to be less than 1.0.

Longitudinals located not more than $0.25D$ above top of keel : $k_0 = \sqrt{\frac{1}{4}\left(3 f_B + \frac{1}{K}\right)}$

Longitudinals located not less than $0.25D$ below deck : $k_0 = \sqrt{\frac{1}{4}\left(3 f_D + \frac{1}{K}\right)}$

Other members : $k_0 = \sqrt{\frac{1}{4}\left(3+\frac{1}{K}\right)}$

(4) Various girders, longitudinal, transverse, vertical or horizontal, the cross ties and end connecting brackets thereof and various bulkhead platings are not to be of less thickness than determined from **Table 7.1.1** according to the length of ship.

Table 7.1.1 Minimum Thickness

Length of ship (m)	Thickness (mm)
$L < 105$	8.0
$105 \leq L < 120$	8.5
$120 \leq L < 135$	9.0
$135 \leq L < 150$	9.5
$150 \leq L < 165$	10.0
$165 \leq L < 180$	10.5
$180 \leq L < 195$	11.0
$195 \leq L < 225$	11.5
$225 \leq L < 275$	12.0
$275 \leq L < 325$	12.5
$325 \leq L < 375$	13.0
$375 \leq L$	13.5

(5) The thickness of flat bar and tripping bracket, etc. fitted up on web of longitudinal girders, transverses and girders of bulkheads is not to be less than that obtained from the following formula. The thickness need not, however, exceed that of web plates to which they are connected.

$$t = 0.5\sqrt{L} + 2.5 \quad (\text{mm})$$

(6) In no case is the thickness of structural members to be less than 7 mm.

109. Direct strength calculation 【See Guidance】

Where approved by the Society, the scantlings of structural members may be determined basing upon direct strength calculation defined in **Pt 3, Ch 1, 206.**

110. Stability Instrument 【See Guidance】

1. All ships, subject to the requirements of the **MARPOL** Annex I shall be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements, approved by the Society having regard to the performance standards recommended by the Organization:

(1) ships constructed before 1 January 2016 shall comply with this requirement at the first scheduled renewal survey of the ship on or after 1 January 2016 but not later than 1 January 2021.

(2) notwithstanding the requirements of (1), a stability instrument fitted on a ship constructed before 1 January 2016 need not be replaced provided it is capable of verifying compliance with intact and damage stability, to the satisfaction of the Society.

(3) However where deemed appropriate by the Society, the requirements of this article **110.** may be exempted, and this exemption shall be specified in **IOPP** form B.

2. In case ships not applied to **1.**, the ships are to be compliance with the relevant regulations of the flag states.

Section 2 Hatchways, Gangways and Freeing Arrangements

201. Ships having unusually large freeboard 【See Guidance】

Relaxation from the requirements specified hereunder will be considered to ships having an extraordinarily large freeboard.

202. Hatchways to cargo oil tanks *(2018)* 【See Guidance】

1. The thickness of coaming plates is not to be less than 10 mm. Where the length and coaming height of a hatchway exceed 1.25 m and 760 mm respectively, vertical stiffeners are to be provided to the side or end coamings and the upper edge of coamings is to be suitably stiffened.
2. Hatchway covers are to be of steel or other approved materials. The construction of steel hatchway covers is to comply with the following requirements. The construction of hatchway covers of materials other than steel is to be in accordance with the discretion of the Society.
   (1) The thickness of cover plates is not to be less than 12 mm.
   (2) Where the area of a hatchway exceeds 1 m^2 but does not exceed 2.5 m^2, cover plates are to be stiffened by flat bars of 100 mm in depth spaced not more than 610 mm apart. Where, however, the cover plates are 15 mm or more in thickness, the stiffeners may be dispensed with.
   (3) Where the area of a hatchway exceeds 2.5 m^2, cover plates are to be stiffened by flat bars of 125 mm in depth spaced not more than 610 mm apart.
   (4) Covers are to be secured oiltight by fastenings spaced not more than 457 mm apart in circular hatchways or 380 mm apart and not more than 230 mm far from the corners in rectangular hatchways.

203. Hatchways to spaces other than for cargo oil tanks *(2021)*

In exposed positions on the freeboard and forecastle decks or on the tops of expansion trunks, hatchways serving spaces other than cargo oil tanks, ballast tank, fuel oil tank and other tanks are to be provided with steel weathertight covers having scantlings complying with the requirements in **Pt 4, Ch 2, Sec 3.**

204. Permanent gangway and passage 【See Guidance】

1. A fore and aft permanent gangway complying with the requirements of **Pt 4, Ch 4, 503.** is to be provided at the level of the superstructure deck between the midship bridge or deck house and the poop or aft deck house, or equivalent means of access is to be provided to carry out the purpose of the gangway, such as passage below deck. Elsewhere and in ships without midship bridge or deck house, arrangements to the satisfaction of the Society are to be provided to safeguard the crew in reaching all parts used in the necessary work of the ship.
2. Safe and satisfactory access from the gangway level is to be available between crew accommodations and machinery space or between separated crew accommodations.

205. Freeing arrangements

1. Ships with bulwarks are to have open rails fitted for at least a half of the length of the exposed part of the freeboard deck or other effective freeing arrangements. The upper edge of sheer strake is to be kept as low as practicable. 【See Guidance】
2. Where superstructures are connected by trunks, open rails are to be provided for the whole length of the exposed parts of the freeboard deck.

Section 3 Longitudinal Frames and Beams in Cargo Oil Spaces

301. General

Longitudinal frames and beams provided in permanent ballast water tanks and cargo oil spaces including void spaces and pump rooms are to be in accordance with the requirements stated hereunder.

302. Scantlings 【See Guidance】

1. The section modulus of bottom longitudinals and side longitudinals including bilge frames is not to be less than that obtained from the formulae given in **Table 7.1.2.**
2. The section modulus of longitudinal beams is not to be less than 1.1 times that obtained from the formula in **Pt 3, Ch 10, 303.**
3. Notwithstanding the provisions in **Pars 1** and **2,** the section modulus of longitudinal frames and beams is not to be less than that obtained assuming them as stiffeners on deep tank bulkhead and taking the distance up to the top of hatchway as h.
4. Longitudinal beams and side longitudinals attached to sheer strake are to be of such dimensions as to have slenderness ratio not exceeding 60 at the midship part as far as practicable. This requirement, however, may be suitably modified for small vessels.
5. As for flat bars used for longitudinal beams and frames, the ratio of depth to thickness is not to exceed 15.
6. The extreme width of face plates of longitudinal beams and frames is not to be less than that obtained from the following formula:

$$b = 2.2\sqrt{d_0 l} \quad (\mathrm{mm})$$

where:

d_0 = depth of web of longitudinal beams or frames (mm).

l = spacing of transverses (m).

303. Attachment 【See Guidance】

Longitudinal frames and beams are to be continuous or to be attached at their ends in such a manner as to effectively develop the sectional area and the resistance to bending.

Table 7.1.2 Section modulus of bottom and side longitudinals

Position	Section modulus (cm^3)	
	Bottom longitudinals	Side longitudinals including bilge frames
Midship part and between a point $0.15L$ from the fore end and the collision bulkhead	$Z = 110 C_1 C_2 K S h l^2$	$Z = 110 C_1 C_2 K S h l^2$ $Z_{min} = 3.2 K \sqrt{L} S l^2$
Forward and afterward end parts	$Z = 93.5 C_1 C_2 K S h l^2$	$Z = 93.5 C_1 C_2 K S h l^2$ $Z_{min} = 2.72 K \sqrt{L} S l^2$

l = spacing of bottom transverses (m).
S = spacing of longitudinals (m).
h = distance from the bottom longitudinal under consideration to the point h' above the top of keel given in the following table (m).
C_1, h', C_2 = as given by the following table.

	C_1	h' (m)	C_2
Bottom longitudinals	$\frac{1}{24 - 15.0 f_B K}$	$h' = d + 0.026L'$	1.0 : Where L is 230 m and under. 1.07 : Where L exceeds 400 m. For the intermediate values of L, C_2 is to be obtained by linear interpolation.
Side longitudinals including bilge frames	$\frac{1}{24 - \alpha K}$	$h' = d + 0.038L'$	

L' = length of ship (m). Where, however, L exceeds 230 m. L' is to be taken as 230 m.
α = either α_1 or α_2 according to value of y. However, value of α is not to be less than β.

$$\alpha_1 = 15.0 f_D \left(\frac{y - y_B}{Y'} \right) \quad \text{for} \quad y \geq y_B$$

$$\alpha_2 = 15.0 f_B \left(\frac{y_B - y}{y_B} \right) \quad \text{for} \quad y < y_B$$

β = coefficient determined according to values of L as specified below :
$\beta = 6/a$ when L is 230 m and under
$\beta = 10.5/a$ when L is 400 m and above
For intermediate values of L, β is to be obtained by linear interpolation.
y = vertical distance (m) from the top of keel to the lower edge of plating when the platings under consideration are under y_B and to the upper edge of plating when the platings under consideration are above y_B, respectively.
Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5) (a) or (b).
a = $\sqrt{K}$, when high tensile steels are used for not less than 80 % of side shell plating at the transverse section amidship and 1.0 for other parts.

Section 4 Girders, Transverses and Cross Ties in Cargo Oil Spaces

401. General 【See Guidance】

1. The requirements specified hereunder are intended to be applied to structures consisting of two to five transverses arranged at approximately equal intervals between transverse bulkheads or between the transverse bulkhead and the wash bulkhead.

2. Girders or transverses in the same plane are to be so arranged that abrupt change in the strength and rigidity is avoided; they are to have brackets of sufficient scantling and with properly rounded corners at their ends.

3. The depth of girders or transverses is not to be less than 2.5 times that of slots for frames, beams and stiffeners.

4. As for the face plates composing girders, the thickness is not to be less than that of web plates and the width of the face plates is not to be less than that obtained from the following formula:

$$b = 2.7\sqrt{d_0 l} \quad (\mathrm{mm})$$

where:

d_0 = depth of girder (mm). In case where it is a balanced girder, d_0 is the depth from the surface of plate to the face plate (mm).

l = distance between supports of girder (m). Where, however, effective tripping brackets are provided, they may be taken as supports.

5. The requirements of **401.** to **406.** are also to be applied to pump rooms, ballast water tanks or void spaces in the midship part so far as practicable.

402. Transverses and girders provided in centre or side tanks in ships having two or more longitudinal bulkheads 【See Guidance】

1. Bottom transverses and bottom girders:

(1) The depth, web thickness and section modulus of bottom transverses and the web thickness and section modulus of bottom girders provided in the middle between longitudinal bulkheads are not to be less than those obtained from the given in **Table 7.1.3** respectively.

(2) Where one or two intercostal side girders are provided between longitudinal bulkhead and bottom girders provided at mid-distance of longitudinal bulkheads, and the bottom transverses are of the reduced scantlings in accordance with (3) below, the sectional area of web plates and moment of inertia of side girders are not to be less than those obtained from the following formulae:

Sectional area of web plates : $A = \alpha_1 \dfrac{L_0}{B_0} d_0 t_0 \quad (\mathrm{cm}^2)$

Moment of inertia : $I = \alpha_2 \left(\dfrac{L_0}{B_0}\right)^3 I_0 \quad (\mathrm{cm}^4)$

where:

α_1, α_2 = coefficients given in **Table 7.1.4.**

I_0 = moment of inertia of bottom transverses (cm^4).

L_0, B_0, d_0, t_0 = as specified in **Table 7.1.3.**

(3) Where intercostal side girders are provided in accordance with (2), the bottom transverses and girders may be of the scantlings obtained from the formulae in (1), using coefficients C_0, C_1, C_2, C_3 and C_4 reduced by 10 % where two transverses are provided and 5 % where three transverses are provided.

(4) In ships without longitudinal centre line bulk heads, a centre girder with brackets at proper intervals is to be provided so as to maintain sufficient strength where the ship is drydocked on keel blocks.

Table 7.1.3 Scantlings of bottom transverses and bottom girders

	Depth (m)	Web thickness (mm)	Section modulus (cm^3)
Bottom transverses	$d = C_0 l_0$	Thickness at the inner edge of bracket attached to longitudinal bulkhead $t = \left(C_1 - 87\frac{b}{l_0}\right)\frac{KQ}{d_0' - a} + 2.5$	$Z = C_2 K k^2 Q l_0$
Bottom girders	–	$t = C_3\frac{\eta KQ}{d_1} + 2.5$	$Z = C_4 K k Q l_1$

Q = $\alpha S h_1 l_0$
α = 1.0 where L is 230 m and under
1.2 where L exceeds 400 m.
For the intermediate values of L, a is to be obtained by linear interpolation.
h_1 = as given by the following formula:
$d + 0.026L'$ (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.
S = spacing of transverses (m), (see **Fig 7.1.2**)
l_0 = overall length of transverses (m). Which is equal to B_0 or $(B_0 - d_3)$ where d_3 depth of vertical web attached to the centre line bulkhead (m).
b = length of horizontal arm of bracket connecting transverse to longitudinal bulkhead (m). (see Fig **7.1.1**)
d_0' = depth of transverse at the inner edge of the above mentioned bracket (mm). (see **Fig 7.1.1**)
a = depth of slot (mm). Where, however, the slots near the inner edge of brackets are provided with collar plates, a may be taken as zero.
d_1' = depth of girder including bracket at the transverse nearest to the bulkhead (mm). (see Fig **7.1.2**)
l_1 = overall length of girder, which is equal to $(L_0 - d_2)$ (m), where d_2 is depth of vertical web on transverse bulkhead (m). (see Fig **7.12**)
k = correction factor due to bracket given by the following formula:

$$k = 1 - \frac{0.65(b_1 + b_2)}{l}$$

b_1, b_2 = arm length of brackets at both ends of girders and transverses respectively (m).
l = overall length of girders and transverses (m), which is equal to l_0 or l_1.
η = as given by the following table.

Number of transverses	$\beta = \frac{S - d_2}{S}$	η
Two rows	$0 \le \beta < \frac{2}{3}$ (See **Fig 7.1.2**)	$\eta = 2 - 1.5\beta$
	$\frac{2}{3} \le \beta$	$\eta = 1.0$
Three to five rows	$0 \le \beta < 0.5$	$\eta = 1.6 - 1.2\beta$
	$0.5 \le \beta$	$\eta = 1.0$

d_0, t_0 = depth (mm) and web thickness (mm) of transverses respectively.
d_1, t_1 = depth (mm) and web thickness (mm) of girders respectively.
B_0 = distance between longitudinal bulkheads (m).
L_0 = distance between transverse bulkheads (m).
C_0, C_1, C_2, C_3, C_4 = as obtained from the following table according to K_0 respectively.

Table 7.1.3 Scantlings of bottom transverses and bottom girders (continued)

Number of transverses	Coef-ficient	$K_0 = \frac{d_0 t_0}{d_1 t_1} \times \frac{L_0}{B_0}$									
		$K_0 \le 0.2$	$0.2 < K_0 \le 0.3$	$0.3 < K_0 \le 0.4$	$0.4 < K_0 \le 0.5$	$0.5 < K_0 \le 0.6$	$0.6 < K_0 \le 0.7$	$0.7 < K_0 \le 0.8$	$0.8 < K_0 \le 1.0$	$1.0 < K_0 \le 1.2$	Where no girder is provided
Two rows	C_0	0.090	0.095	0.100	0.105	0.115	0.115	0.120	0.125	0.135	0.160
	C_1	23.6	24.3	25.5	26.7	27.8	29.0	30.1	31.8	34.0	43.7
	C_2	1.44	1.47	1.54	1.63	1.77	1.94	2.12	2.43	2.87	5.69
	C_3	36.8	34.5	32.3	30.5	28.5	26.6	24.8	22.2	18.8	–
	C_4	8.08	7.65	7.04	6.51	6.25	5.73	5.21	4.09	4.17	–
Three rows	C_0	0.090	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.160
	C_1	24.0	25.5	26.7	27.8	29.4	30.5	31.7	33.6	36.3	43.7
	C_2	1.47	1.54	1.63	1.79	1.96	2.19	2.43	2.84	3.41	5.69
	C_3	57.2	54.0	50.9	47.5	44.6	42.3	39.9	36.0	31.3	–
	C_4	10.42	9.65	8.97	8.34	7.67	7.06	6.51	5.73	4.69	–
Four rows	C_0	0.090	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.160
	C_1	24.4	25.9	27.1	28.6	30.0	31.3	32.7	34.8	37.5	43.7
	C_2	1.47	1.54	1.70	1.87	2.03	2.28	2.52	3.01	3.73	5.69
	C_3	76.0	68.1	64.2	60.3	56.4	52.5	48.5	43.5	36.8	–
	C_4	10.69	9.65	88.6	8.08	7.34	6.80	5.99	5.27	4.17	–
Five rows	C_0	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.145	0.160
	C_1	24.7	26.3	27.4	29.4	30.9	32.5	34.0	36.7	40.2	43.7
	C_2	1.54	1.63	1.79	2.03	2.28	2.52	2.83	3.50	4.46	5.69
	C_3	94.0	83.8	78.3	72.8	67.5	62.6	57.2	49.5	39.2	–
	C_4	15.64	13.56	12.50	11.46	10.16	9.12	8.08	6.78	4.69	–

NOTES :
1. Where strong vertical girders are provided on transverse bulkheads at one side only in case of four or five transverses, coefficient C_4 is to be increased appropriately.
2. Where the depth of centre line bottom girder is of extremely large depth, coefficient, coefficient C_4 may be suitably modified.

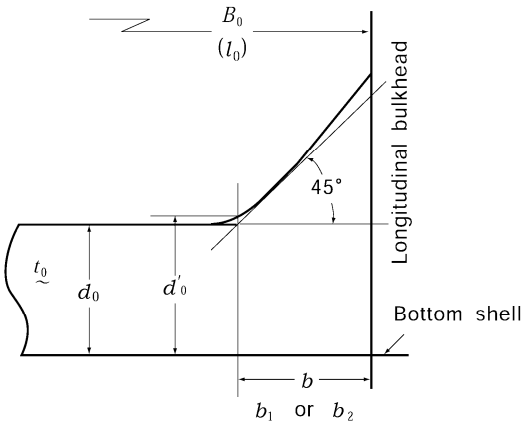


Fig 7.1.1 Measurement of b, d_0, d'_0 etc.

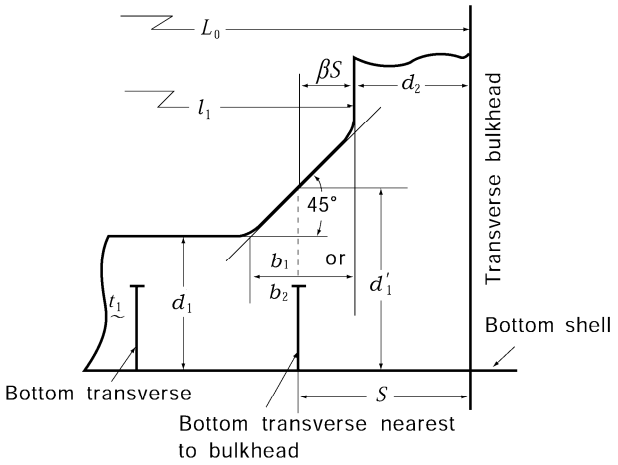


Fig 7.1.2 Measurement of d_1, d'_1, d_2, S etc.

Table.7.1.4 Coefficients α_1 and α_2

Number of side girders	Coefficient	
	α_1	α_2
1	0.0085	0.67
2	0.0045	0.42

2. Deck transverses and girders

(1) The depth and section modulus of deck transverses are not to be less than those obtained from the following formulae:

Depth of transverses : $d = C_0 l_0 \quad (\mathrm{m})$

Section modulus of transverses : $Z = CKk^2\sqrt{L}\,S l_0^2 \quad (\mathrm{cm}^3)$

where :

C_0, C = coefficients given in **Table 7.1.5** respectively.

d_0, t_0 = depth (mm) and web thickness (mm) of transverses respectively.

d_1, t_1 = depth (mm) and web thickness (mm) of girders respectively.

L_0, B_0, S, k = as specified in **Table 7.1.3.**

l_0 = overall length of transverses (m), which is equal to B_0 or $(B_0 - d_3)$, where d_3 is depth of vertical web on centre line bulkhead (m).

Table 7.1.5 Coefficients C_0 and C

Number of transverses	$K_0 = \frac{d_0 t_0}{d_1 t_1} \times \frac{L_0}{B_0}$	C_0	C
Two and three	$K_0 \leq 0.5$	0.07	0.79
	$K_0 \geq 1.5$	0.10	1.82
Four	$K_0 \leq 0.4$	0.07	0.79
	$K_0 \geq 1.4$	0.10	1.82
Five	$K_0 \leq 0.3$	0.07	0.79
	$K_0 \geq 1.3$	0.10	1.82
NOTE: For intermediate values of K_0, C_0 and C are to be obtained by linear interpolation.			

(2) Deck girders provided at the mid-distance of longitudinal bulkheads may be of scantlings determined in relation to those of deck transverse specified in (1). Where deck girders from a ring system together with strong vertical webs on transverse bulkheads as specified in **505.**, the depth of girders is not to be less than that obtained from the following formula.

$$d = \frac{L_0 D}{9 B_0} \quad (\mathrm{m})$$

where:

B_0, L_0 = as specified in **Table 7.1.3.**

3. Transverses provided on longitudinal centre line bulkheads are not to be of less scantling than determined in accordance with **403. 2**(2) for transverses on longitudinal bulkheads in wing tanks.

403. Transverses and girders provided in wing tanks in ships having two or more longitudinal bulkheads 【See Guidance】

1. Side transverses

(1) Symbols used in this Paragraph are defined as follows:

$$Q = \alpha S h l_0$$

α = 1.0 where L is 230 m and under,
1.2 where L exceeds 400 m
For intermediate values of L, α is to be obtained by linear interpolation.

h = distance from the mid-point of l_0 to the point H_2 above the top of keel (m).

h_s = distance from the mid-point of b_s to the point H_2 above the top of keel (m).

$$H_2 = d + 0.038L' \quad (\mathrm{m})$$

L' = length of ship (m). Where L' exceeds 230 m, L' is to be taken as 230 m.

l_0 = overall length of side transverses (m), which is equal to the distance between the inner surfaces of face plates of bottom transverses and deck transverses. (See Fig **7.1.3**)

S = spacing of transverses (m).

S' = spacing of stiffeners provided depthwise on the web plates of transverses at the portion where cross ties are connected (m).

k = as specified in **Table 7.1.3.**

b = length of arm of the lowest bracket (m). (See Fig **7.1.3**)

b_s = width of the area supported by cross ties (m). (See Fig **7.1.3**)

d_0' = depth of side transverses at the inner edge of the lowest bracket (mm). (See Fig **7.1.3**)

a = depth of slot in the vicinity of inner edge of the lowest bracket. Where, however, the slots are provided with collar plates, a may be taken as zero.

A = section area effective to support the axial force from cross tie (cm^2), which is to be taken as follows:

(a) Where the face plates of cross ties are continuous to the face plates of transverses in an arc form or a similar form, A is the total sum of the sectional area of the web plate of transverse at the portion between the contact points of the tangents to the arc or the similar curve making an angle of 45° to the direction of cross tie, that of the stiffener provided in the axial direction of cross tie on the web plate between the contact points, and 0.50 times that of the face plates at the contact points. (See Fig **7.1.4** (a))

(b) Where the face plates of cross ties are continuous to the face plates of transverses in the form of straight line with rounded corners, A is the total sum of the sectional area of the web plate of transverse at the portion between the midpoints of the intersections of the extensions of the lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the inner surface of face plates at the transforming parts, that of the stiffener provided in the axial direction of cross tie on the web plate between the above mentioned mid-points and 0.50 times that of the face plates at the mid-points. (See Fig **7.1.4** (b))

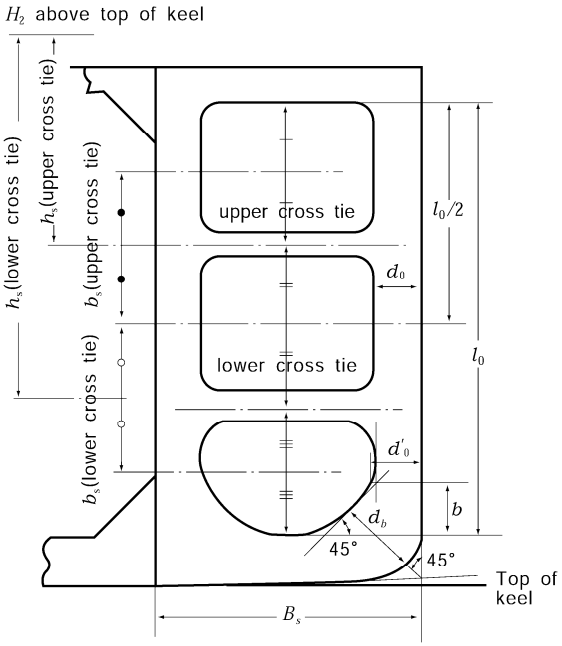


Fig 7.1.3 Measurement of l_0, d'_0, b, b_s, etc.

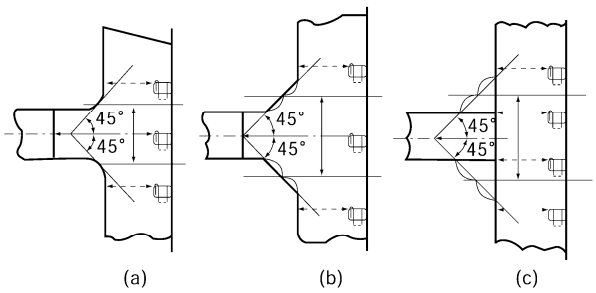


Fig 7.1.4 Extent for total sectional area

(c) Where the face plates of cross ties are joined directly to the face plates of transverses with a right or nearly right angle and both face plates are connected with brackets and further, stiffeners are provided on the web plate of transverses on the extended lines of face plates of cross tie, A is the total sum of the sectional area of the web plate of transverse at the portion between the mid-points of the intersections of the extensions of lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the free edge lines of brackets, and that of the stiffeners provided as mentioned above. (See Fig **7.1.4** (c))

C_0, C_1, C_2 = coefficients given in **Table 7.1.6** according to the number of cross ties respectively.

Table 7.1.6 Coefficients C_0, C_1, C_2 and C_2'

Number of cross ties	C_0	C_1	C_2	C_2'
0	0.150	55.7	5.07	7.14
1	0.110	44.8	2.70	4.42
2	0.100	39.4	2.28	3.74
3	0.095	36.2	2.12	3.49

(2) The depth of transverses is not to be less than $C_0 l_0$ (m) at the mid-point of l_0. Where the transverses are of tapered form, the reduction in depth at the upper end is not to exceed 10 % of the depth at the mid-point of l_0, and the rate of increase in depth at the lower end is not to be less than that of reduction at the upper end.

(3) The web thickness of transverses at the inner edge of brackets at the lower ends is not to be less than that obtained from the following formula. Where, however, bottom transverses and longitudinal bulkheads in centre tanks or inner tanks are connected with large brackets extending to the lowest cross ties, the web thickness of side transverses may be properly reduced.

$$t = \left(C_1 - 148 \frac{b}{l_0} \right) \frac{KQ}{d_0' - a} + 2.5 \quad (\mathrm{mm})$$

(4) The web thickness of transverses at the portion where cross ties are connected is not to be less than that obtained from the following formula. Where slots are provided in the web at the portion where cross ties are connected, the slots are to be effectively covered with collar plates.

$$t = 16 \sqrt{\frac{\alpha S b_s h_s}{A}} \times S' \quad (\mathrm{mm})$$

(5) The section modulus of transverses at the span is not to be less than that obtained from the following formula :

$$Z = C_2 K k^2 Q l_0 \quad (\mathrm{cm}^3)$$

2. Vertical webs on longitudinal bulkheads

(1) Vertical webs on longitudinal bulkheads connected to side transverses with effective cross ties are to be of the scantlings required in **Par 1** for side transverses with cross ties.

(2) Vertical webs on longitudinal bulkheads without cross ties are generally to be of the scantlings required in **Par 1** for side transverses without cross ties. However, h is to be the distance from the mid-point of l_0 to the top of hatches of inner tanks or centre tanks (m).

3. Bottom transverses

(1) The rigidity of bottom transverses is to be well balanced with that of side transverses.

(2) The section modulus of bottom transverses at the span is not to be less than that obtained from the following formula:

$$Z = 9.3 K \alpha k^2 S h_1 l_1^2 \quad (\mathrm{cm}^3)$$

where :

α, k, S = as specified in **Par 1** (1).

h_1 = as specified in **Table 7.1.3.**

l_1 = overall length of bottom transverses (m), which is equal to the distance between the inner surface of face plates of bottom transverses and that of vertical webs on longitudinal bulkheads.

(3) The section modulus of transverses at bilge and at the lower end of longitudinal bulkheads is not to be less than that obtained from the following formula. Where, however, bottom transverses and vertical webs on longitudinal bulkheads in centre tanks or inner tanks are connected with large brackets extending to the lowest cross ties, the section modulus of transverses specified above may be properly reduced. In calculating the section modulus, the neutral axis of section is to be taken as located at the middle of the depth d_b (See Fig **7.1.3**) of transverses.

$$Z = C_2' K Q l_0 \quad (\mathrm{cm}^3)$$

where:

Q, l_0 = as specified in **Par 1** (1) respectively.

C_2' = coefficient given in **Table 7.1.6** according to the number of cross ties.

4. Deck transverses

(1) The rigidity of deck transverses is to be well balanced with that of side transverses.

(2) The section modulus of deck transverses is not to be less than that obtained from the following formula:

$$Z = 3Kk^2S\sqrt{L}\,l_2^{\,2} \quad (\mathrm{cm}^3)$$

where:

k, S = as specified in **Par** 1(1) respectively.

l_2 = overall length of deck transverses (m), which is equal to the distance between the inner edges of face plates of side transverses and that of vertical webs on longitudinal bulkheads.

5. Transverses and girders where longitudinal girders are provided on ship's side and on longitudinal bulkheads

The requirements in this paragraph are intended to be applied to the structures consisting of one, two or three side stringers or horizontal girders and three transverses in association with cross ties provided only at the crossing point of middle transverses and side stringers to connect ships sides to longitudinal bulkheads.

(1) The scantlings of side transverses and the section modulus of transverses at bilge are not to be less than those obtained from the formulae given in **Pars 1** and **3** respectively, using C_0, C_1, C_2, and C_2' as given in **Table 7.1.7** according to the value of K given by the following formula :

$$K = \frac{d_0}{d_1}\left(\frac{l_1}{l_0}\right)^2$$

where:

d_0 = mean depth of side transverses (mm).

l_0 = as specified in **Par 1**(1).

d_1 = mean depth of side stringers (mm).

l_1 = overall length of side stringers (m), which is equal to the distance between transverse bulkheads minus the depth of horizontal girders on transverse bulkheads.

(2) The section modulus of side stringers and the web thickness of side stringers in the span from the end of side stringer to the crossing point of side stringer and side transverse at the end are not to be less than those obtained from the following formulae respectively. Where three side stringers are provided, the web thickness of the uppermost stringers may be properly reduced.

Web thickness : $t = C_3K\dfrac{Q}{d_1} + 2.5 \quad (\mathrm{mm})$

Section modulus of side stringer : $Z = C_4KkQl_1 \quad (\mathrm{cm}^3)$

where :

Q, k = as specified in **Par 1** (1) respectively.

d_1, l_1 = as specified in (1) respectively.

C_3, C_4 = coefficients given in **Table 7.1.7** according to the value of K.

Table 7.1.7 Coefficients C_0, C_1, C_2, C_2', C_3 and C_4

Number of girders	Coeffic-ient	$K = \frac{d_0}{d_1}\left(\frac{l_1}{l_0}\right)^2$											
		$K \le 0.2$	$0.2 < K \le 0.3$	$0.3 < K \le 0.4$	$0.4 < K \le 0.5$	$0.5 < K \le 0.6$	$0.6 < K \le 0.7$	$0.7 < K \le 0.8$	$0.8 < K \le 0.9$	$0.9 < K \le 1.0$	$1.0 < K \le 1.2$	$1.2 < K \le 1.4$	$1.4 < K \le 1.6$
one	C_0	0.070	0.080	0.085	0.090	0.095	0.095	0.100	0.100	0.100	0.105	0.105	0.110
	C_1	36.9	37.8	39.0	40.0	41.1	41.8	42.5	42.9	43.2	43.6	43.9	44.3
	C_2	1.44	1.60	1.77	1.89	2.03	2.11	2.22	2.29	2.37	2.45	2.53	2.63
	C_2'	2.89	3.06	3.23	3.40	3.55	3.69	3.81	3.91	4.00	4.08	4.18	4.24
	C_3	45.0	39.6	36.9	34.5	32.4	30.6	28.9	27.4	26.1	24.3	22.0	19.8
	C_4	4.06	3.55	3.26	3.03	2.81	2.61	2.44	2.30	2.16	2.00	1.85	1.70
Two	C_0	0.060	0.072	0.075	0.080	0.085	0.085	0.090	0.090	0.090	0.095	0.095	0.100
	C_1	27.2	29.1	30.8	32.4	33.4	34.3	35.1	35.7	36.3	37.1	38.0	38.9
	C_2	0.76	0.93	1.10	1.25	1.40	1.51	1.61	1.70	1.81	1.94	2.11	2.19
	C_2'	1.62	1.87	2.13	2.34	2.55	2.72	2.89	30.4	3.13	3.31	3.46	3.57
	C_3	30.6	27.9	26.0	24.3	23.0	21.8	20.7	19.7	18.7	17.3	15.3	13.5
	C_4	2.96	2.66	2.48	2.30	2.14	1.98	1.85	1.72	1.62	1.48	1.33	1.18
Three	C_0	1.050	0.060	0.065	0.070	0.075	0.080	0.080	0.085	0.085	0.090	0.090	0.095
	C_1	23.2	25.1	26.8	28.1	29.2	30.2	31.1	32.0	32.9	33.9	34.8	35.7
	C_2	0.050	0.68	0.84	0.98	1.11	1.24	1.35	1.44	1.53	1.69	1.86	2.03
	C_2'	1.19	1.45	1.70	1.87	2.10	2.30	2.47	2.64	2.78	2.98	3.15	3.32
	C_3	26.1	24.3	23.4	22.5	21.6	20.7	19.8	18.9	18.0	16.7	15.0	13.2
	C_4	2.52	2.22	2.07	1.92	1.78	1.66	1.56	1.47	1.39	1.26	1.11	0.96

NOTE:
1. Where two side stringers are provided, $1.2C_3$ and $1.2C_4$ are to be used for the lower stringer, and $0.8C_3$ and $0.8\ C_4$ for the upper stringer, in place of C_3 and C_4 respectively.
2. Where three side stringers are provided, $1.3C_4$ is to be used for the lowest stringer, and $0.7C_4$ for the uppermost stringer, in place of C_4 respectively.

(3) The web thickness of transverses and side stringers at the portion where cross ties are connected is not to be less than that determined in accordance with **Par 1** (4). However, in the formula therein:

S = a half of l_1 specified in (1).

S' = spacing of stiffeners provided in depthwise on webs of side transverses and vertical webs on longitudinal bulkheads, or on side stringers and stringers on longitudinal bulkheads respectively at the portion where the cross ties are connected (m).

A = effective sectional area to support the axial force from cross ties (cm^2). Where cross ties consist of the members provided both on web plate of transverses and stringers, the area is equal to the total sectional area of these members which are to be determined in general as required in **Par 1** (1).

(4) Vertical webs and horizontal girders on longitudinal bulkheads are not to be of less scantlings than determined in accordance with (1) and (2).

(5) Where n tiers of horizontal girders are provided, the distances between the girders, the girder and the deck, and the girder and the top of keel are not to be less than $0.85\ D/(n+1)$ nor more than $1.15\ D/(n+1)$ as far as practicable.

(6) Where two or more horizontal girders are provided, the uppermost girder may, if properly arranged, be of the depth reduced by not more than 10% from the mean depth of the girders.

404. Cross ties 【See Guidance】

1. In ships having two or more longitudinal bulkheads where side transverses and vertical webs on longitudinal bulkheads in wing tanks are connected with cross ties and where the structural arrangements are as given in **403. 5,** the cross ties are to be in accordance with the following requirements.

2. As regards the spacing of cross ties, the requirements in **403. 5** (5) are to be applied in general.

3. The sectional area of cross ties connecting side transverses to vertical webs on longitudinal bulkheads in wing tanks is not to be of less than section area obtained from the formula given in **Table 7.1.8.**

4. (1) Brackets are to be provided at the ends of cross ties to connect to transverses or girders.
(2) Transverses are to be provided with tripping brackets at the junction with cross ties.
(3) Where the breadth of face plates forming cross ties exceeds 150 mm on one side of the web, stiffeners connected to web and face plates are to be fitted at proper intervals.

Table 7.1.8 Section area of cross tie and thickness of web

Section area (cm^2)	Thickness of web (mm)
Whichever is the greater : $A = \dfrac{0.77K\alpha S b_s h_s}{1-0.5\dfrac{l}{k\sqrt{K}}}$, $A = 1.1K\alpha S b_s h_s$	$t = 16\sqrt{\dfrac{\alpha S b_s h_s}{A}} \times d_0$

α = as specified in **403. 1** (1).
S = spacing of transverses (m). Where, however, constructed as specified in **403. 5,** S is to be taken as a half of l_1 specified in **403. 5** (1) (m).
b_s = width of the area supported by cross ties (m). (See Fig **7.1.3**).
h_s = distance from the mid-point of b_s to the point H_2 specified in **403. 1** (1) above the top of keel (m).
l = length of cross ties measured between the inner edges of the side transverses (or stringers) and the vertical webs (or horizontal girders) on longitudinal bulkheads (m).
k $= \sqrt{I/A}$ (cm)
I = the least moment of inertia of cross ties (cm^4).
A = sectional area of cross ties (cm^2).
d_0 = depth of web plates (mm). Where, however, stiffeners are provided lengthwise on the web plates, the depth may be considered to be divided by the stiffeners.

405. Minimum thickness of web plates, scantling of stiffeners

1. (1) The web thickness of girders situated below the position of approximately $0.25D$ above the top of keel is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater.

$$t = 13.2\frac{Cd_0}{\sqrt{K}} + 2.5 \quad (\text{mm})$$

where :
d_0 = depth of web plates (m). Where stiffeners are provided horizontally on the midpart of web plates, distance between the stiffener and shell plating or face plate (m), or between the stiffeners (m).
C = coefficient which is determined from **Table 7.1.9** according to the ratio of S to d_0 where S is the spacing of stiffeners provided on web plates in the depthwise (m).

Table 7.1.9 Coefficient C

S/d_0	C
$\frac{S}{d_0} \geq 1.0$	1.0
$\frac{S}{d_0} < 1.0$	$\sqrt{\frac{S}{d_0}}$

(2) The web thickness of girders situated above the position of approximately $0.25D$ below the lower edge of deck at ships sides is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater:

$$t = 11.0\frac{Cd_0}{\sqrt{K}} + 2.5 \quad (\text{mm})$$

where :

d_0, C = as specified in (1).

(3) The web thickness of transverse girders and longitudinal girders other than those specified in the above (1) and (2) is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater. The girders situated higher than $D/3$ above the top of keel or the lower edge of face plate at the lower side of the second cross ties from deck, whichever is the lower, may have the web thickness as obtained from the formula with its first term multiplied by 0.85, subject to the requirements of (i) and (ii) in this Sub-paragraph (b).

$$t = \frac{Cd_0}{\sqrt{K}} + 2.5 \quad (\text{mm})$$

where:

d_0 = as specified in (1).

C = coefficient determined from **Table 7.1.10,** according to the ratio of S to d_0 and the stiffened panel arrangement, where S is the spacing of stiffeners provided on web plates in the depthwise (m). For the intermediate value of S/d_0, C is to be obtained by linear interpolation.

Table 7.1.10 Coefficients C_1, C_2 and C_3

S/d_0	C_1	C_2	C_3
0.2 or less	2.6	2.1	3.7
0.4	4.5	3.7	6.7
0.6	5.6	4.9	8.6
0.8	6.4	5.8	9.6
1.0	7.1	6.6	9.9
1.5	7.8	7.4	10.3
2.0	8.2	7.8	10.4
2.5 or more	8.4	8.0	10.4

(a) Where no stiffener is provided in parallel with face plates ..... C_1
Where, however, slots are provided, C_2 is to be used and the web thickness is not to be less than that obtained by applying the requirements of (i) in this sub-paragraph.

(b) Where stiffeners are provided in parallel with face plates,
For panel between face plate and stiffener or between stiffeners ..... C_3
However, the thickness need not exceed the value obtained by using coefficient C_1, Subject to no stiffener in parallel to face plate and no slot being provided. For panel between stiffener and shell plating ..... C_2

(i) Where slots are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$\sqrt{4.0\frac{d_1}{S}-1.0}$$

where d_1/S is 0.5 or less, the multiplier is to be taken as 1.0.

where :

d_1 = depth of slots (m).

(ii) Where openings are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$1+0.5\frac{\phi}{a}$$

where:

a = length at the longer side of the panel surrounded by the web stiffeners (m).

ϕ = diameter of openings (m). Where openings are of oblong, ϕ is to be the length of the longer diameter (m).

(4) The depth of flat bar stiffeners provided on girders and transverses is not to be less than 0.08 d_0. Where, however, the stiffeners are fitted to the full depth of girders, d_0 is to be taken as the depth of girders, and where the stiffeners are fitted to the length from the top of longitudinal frames which penetrate girders to the face plate of girders, d_0 is to be taken as the depth of girders minus the height of longitudinal frames, and where the stiffeners are fitted in parallel with face plates, d_0 is to be taken as the spacing of tripping brackets.

(5) Tripping brackets are to be provided on the web plate of transverses at the inner edge of end brackets and at the connecting part of crossties, etc. and also at the proper intervals in order to support transverses effectively. Where the breadth of face plates exceeds 180 mm on one side of the web, the tripping brackets are to be connected to face plates as well.

2. Where horizontal flat bar stiffeners are provided on bottom and deck girders, the stiffeners are not to be of less depth than 0.06 l, notwithstanding the requirements in **Par 1** (4). For strong bottom girders supporting bottom transverses, however, the horizontal stiffeners are not to be of less depth than 0.08 l, where l is the spacing of transverses (m), except that where brackets extending for the full depth of girders are provided at the midpoint of l, l may be taken as a half of the spacing of transverses.

3. Where flat bar stiffeners are connected at their ends to face plates, tripping brackets, etc., the depth of stiffeners as specified in **Par 1** (4) and **Par 2** may be properly reduced.

406. Special consideration on stiffening girders, webs and end connection brackets

Connecting brackets of bottom transverses to web plates on longitudinal bulkheads and the web plates in the vicinity of the inner edge of connecting brackets, and connecting brackets of bottom girders to web plates on transverse bulkheads (oiltight, watertight and wash) and the web plates in the vicinity of the inner edge of connecting brackets which are respectively situated in centre tanks or inner tanks, and side transverses and connecting brackets at the lower end of vertical webs on longitudinal bulkheads and the web plates in the vicinity of the inner edge of connecting brackets, and connecting brackets of side stringers to web plates on transverse bulkheads and the web plates

in the vicinity of the inner edge of connecting brackets which are respectively situated in wing tanks, are to be specially provided with stiffeners in a close spacing. Further, on the web plates at the portions specified above is to be given a special consideration to prevent buckling, where the plates are unavoidably lap jointed.

Section 5 Bulkheads in Cargo Oil Spaces

501. Sectional area of transverse bulkhead plating in centre tanks

The sectional area of transverse bulkhead plating in the depthwise direction of ship in centre tanks is not to be less than that obtained from the following formula :

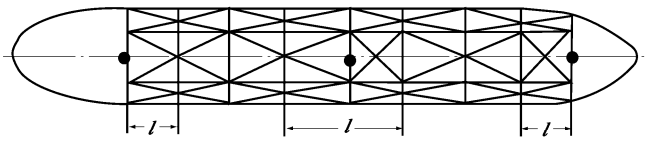
$$A = 0.95KS(h-0.32d)(l-S)\left(C+\frac{Y}{l-S}\right) \quad (\mathrm{cm}^2)$$

where :

S = spacing of bottom transverses (m).

h = distance from the top of keel to the top of hatches in centre tanks (m).

l = distance between two bulkheads of watertight, oiltight or wash, which are situated respectively forward and afterward of the bulkhead concerned (m). Where the bulkhead concerned, however, is situated at the fore or after end of cargo oil spaces, l is to be the distance from such end bulkhead to the bulkhead of watertight, oiltight or wash, which is situated forward or afterward of the bulkhead respectively (m). (See Fig **7.1.5**)



● marks show the bulkheads concerned

Fig 7.1.5 Measurement of l

Y = distance measured athwartship from ship's centre line (m).

C = coefficient which is to be taken as zero where no centre line girder is provided in the bottom structure of centre tanks, and to be obtained from the following formula where centre line girder is provided :

$$C = \frac{0.175}{1+131.0\frac{a}{D}\left(\frac{1.5K_b^3}{1+15.6K_b^2}+\frac{K_d^3}{1+15.6K_d^2}\right)} \times \frac{a}{S}$$

where:

a = half-breadth of centre tanks (m).

K_b, K_d = ratio of h_b/l and h_d/l, respectively, where h_b is the height of centre line bottom girder (m) and h_d is the height of centre line deck girder (m).

502. Thickness of bulkhead plating

1. The thickness of bulkhead plating is not to be less than that obtained from the formula in Pt 3, **Ch 15, 202.** for deep tank bulkhead plating, using h measured from the lower edge of plating to the top of hatches (m) or $0.3\sqrt{L}$ (m), whichever is the greater.
2. The breadth of the uppermost and lowest strakes of longitudinal bulkhead plating is not to be less than $0.1D$ and the thickness of these is not to be less than that obtained from the following formulae : **【See Guidance】**

   For lowest strakes : $t = 1.1S\sqrt{KL} + 2.5 \quad (\mathrm{mm})$

   For uppermost strakes : $t = 0.85S\sqrt{KL} + 2.5 \quad (\mathrm{mm})$

   where:
   S = spacing of stiffeners (m).
3. The thickness of longitudinal bulkhead plating is to comply with the requirements of **Pt 3, Ch 3, Secs 3** and **4.**

503. Stiffeners

1. The section modulus of stiffeners is not to be less than that obtained from the formula in **Pt 3, Ch 15, 203.** and **207.** for deep tank bulkhead stiffeners, using h measured from the midpoint of l in case of vertical stiffeners or from the centre of the width of plating supported by the stiffener in case of horizontal stiffeners to the top of hatches (m) or $0.3\sqrt{L}$ (m), whichever is the greater.
2. Horizontal stiffeners provided on upper and lower parts of longitudinal bulkhead plating are to be of increased scantling above those specified in the preceding Paragraph.
3. The full width of face plates of horizontal stiffeners on longitudinal bulkhead is not to be less than that required in **302. 6.**

504. Strong vertical webs 【See Guidance】

Where strong vertical webs are provided in support of horizontal girders on transverse bulkheads at the mid-distance of longitudinal bulkheads, the vertical webs are to be in accordance with the following requirements, according to the case where transverse bulkhead is of vertical stiffener system or horizontal stiffener system.

(1) In the case of vertical stiffener system, the depth, web thickness and section modulus of strong vertical webs supporting horizontal girders are not to be less than those obtained from the following formulae respectively. (See Fig **7.1.6**)

Depth of webs : $d = 3\left(\frac{l_1}{B_0}\right)^2 d_0 \quad (\mathrm{mm})$

Web thickness :
Web thickness of vertical webs in the portion between the top of face plate of bottom girder and the horizontal girder just above the bottom girder, and web thickness of vertical webs in the portion between the said horizontal girder and the horizontal girder just above it in case where the said horizontal girder is provided within 1/3 length of vertical arm of bracket at the lower end of vertical webs above the face plate of bottom girder:

In case of one horizontal girder :

$$t_1 = \frac{87}{d_l} KW_1 \left(\frac{a_1}{l_1}\right)^2 \left(1 + \frac{2a_2}{l_1}\right) + 2.5 \quad (\mathrm{mm})$$

In case of two horizontal girders :

$$t_2 = \frac{87}{d_l} K \left[W_1 \left(\frac{a_1}{l_1} \right)^2 \left\{ 1 + \frac{2(a_2 + a_3)}{l_1} \right\} \right]$$

In case of three horizontal girders :

$$t_3 = \frac{87}{d_l} K \left[W_1 \left(\frac{a_1}{l_1} \right)^2 \left\{ 1 + \frac{2(a_2 + a_3 + a_4)}{l_1} \right\} + W_2 \left(\frac{a_1 + a_2}{l_1} \right)^2 \left\{ 1 + \frac{2(a_3 + a_4)}{l_1} \right\} + W_3 \left(\frac{a_1 + a_2 + a_3}{l_1} \right)^2 \left(1 + \frac{2a_4}{l_1} \right) \right] + 2.5 \quad (\text{mm})$$

In case of n horizontal girders : $t_n = \frac{87}{d_l} K \left[\sum_{i=1}^{n} W_i \left(\sum_{j=1}^{i} \frac{a_j}{l_1} \right)^2 \left(1 + 2 \sum_{k=i+1}^{n+1} \frac{a_k}{l_1} \right) \right] + 2.5 \quad (\text{mm})$

Thickness of vertical webs in the portion between the lower surface of face plate of deck girders and the horizontal girder just below the said face plate.

In case of one horizontal girder : $t_1 = \frac{87}{d_u} K W \left(\frac{a_2}{l_1} \right)^2 \left(1 + \frac{2a_1}{l_1} \right) + 2.5 \quad (\text{mm})$

In case of two horizontal girders :

$$t_2 = \frac{87}{d_u} K \left[W_1 \left(\frac{a_1 + a_2}{l_1} \right)^2 \left(1 + \frac{2a_1}{l_1} \right) + W_2 \left(\frac{a_3}{l_1} \right)^2 \left\{ 1 + \frac{2(a_1 + a_2)}{l_1} \right\} \right] + 2.5 \quad (\text{mm})$$

In case of three horizontal girders :

$$t_3 = \frac{87}{d_u} K \left[W_1 \left(\frac{a_2 + a_3 + a_4}{l_1} \right)^2 \left(1 + \frac{2a_1}{l_1} \right) + W_2 \left(\frac{a_3 + a_4}{l_1} \right)^2 \left\{ 1 + \frac{2(a_1 + a_2)}{l_1} \right\} + W_3 \left(\frac{a_4}{l_1} \right)^2 \left\{ 1 + \frac{2(a_1 + a_2 + a_3)}{l_1} \right\} \right] + 2.5 \quad (\text{mm})$$

In case of n horizontal girders : $t_n = \frac{87}{d_u} K \left[\sum_{i=1}^{n} W_i \left(\sum_{j=i+1}^{n+1} \frac{a_j}{l_1} \right)^2 \left(1 + 2 \sum_{k=1}^{i} \frac{a_k}{l_1} \right) \right] + 2.5 \quad (\text{mm})$

Section modulus of webs : $Z = 4 K k^2 B_0 h l_1^2 \quad (\text{cm}^3)$

where:

l_1 = overall length of vertical webs (m), which is equal to the distance between the inner surface of face plates of bottom and deck girders. In case where horizontal girder is provided within 1/3 of the length of vertical arm of bracket at the lower end of vertical webs above the top of bottom girders, l_1 is to be the distance between the said horizontal girder and the inner surface of face plate of deck girders (m).

B_0 = distance between longitudinal bulkheads (m)

d_0 = mean depth of horizontal girders (m).

d_l = depth of webs at the lower portion of vertical webs considered (mm).

d_u = depth of webs at the upper portion of vertical webs considered (mm).

n = number of horizontal girders provided within the length of l_1.

W_i (i = 1, 2,...n) = load which vertical webs receive from the number n horizontal girder counting from the top of l_1 and which is obtained from the following formulae :

In case of one horizontal girder : $W_1 = \frac{B_0}{4}(a'_1 + a'_2)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a'_2\right)$ (t)

In case of two horizontal girders :

$$W_1 = \frac{B_0}{4}(a'_1 + a_2)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \quad \text{(t)}$$

$$W_2 = \frac{B_0}{4}(a_2 + a'_3)\left(h' + a'_1 + \frac{3}{4}a_2 + \frac{1}{4}a'_3\right) \quad \text{(t)}$$

In the case of three horizontal girders :

$$W_1 = \frac{B_0}{4}(a'_1 + a_2)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \quad \text{(t)}$$

$$W_2 = \frac{B_0}{4}(a_2 + a_3)\left(h' + a'_1 + \frac{3}{4}a_2 + \frac{1}{4}a_3\right) \quad \text{(t)}$$

$$W_3 = \frac{B_0}{4}(a_3 + a'_4)\left(h' + a'_1 + a_2 + \frac{3}{4}a_3 + \frac{1}{4}a'_4\right) \quad \text{(t)}$$

In case of n horizontal girders :

$$W_1 = \frac{B_0}{4}(a'_1 + a_2)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \quad \text{(t)}$$

$$W_i = \frac{B_0}{4}(a_i + a_{i+1})\left(h' + \sum_{j=1}^{i-1}a_j + \frac{3}{4}a_i + \frac{1}{4}a_{i+1}\right) \quad \text{(t)} \qquad (i = 2, 3 \ldots\ldots, n-1)$$

$$W_n = \frac{B_0}{4}(a_n + a'_{n+1})\left(h' + \sum_{j=1}^{n-1}a_j + \frac{3}{4}a_n + \frac{1}{4}a'_{n+1}\right) \quad \text{(t)}$$

Where

j = 1 in the above formulae for W_i and W_n, a_i is to be taken as a'_1.

where :

a_i (i = 1, 2, ..., n) = distance between the top of l_1 and the horizontal girder just below the top, distance between the adjacent horizontal girders or distance between the bottom of l_1 and the horizontal girder just above the bottom (m). (i is to be counted from the top.)

a'_1 = distance between the lower surface of deck longitudinals and the uppermost horizontal girder (m).

a'_{n+1} = distance from the lowest horizontal girder within the length of l_1 to the horizontal girder just below it or to the upper surface of bottom longitudinals (m).

h = distance from the mid-point of l_1 to the top of hatchways in centre tanks (m).

h' = distance from the lower surface of deck longitudinals to the top of hatchways in centre tanks (m).

k = correspondingly as specified in **Table 7.1.3.**

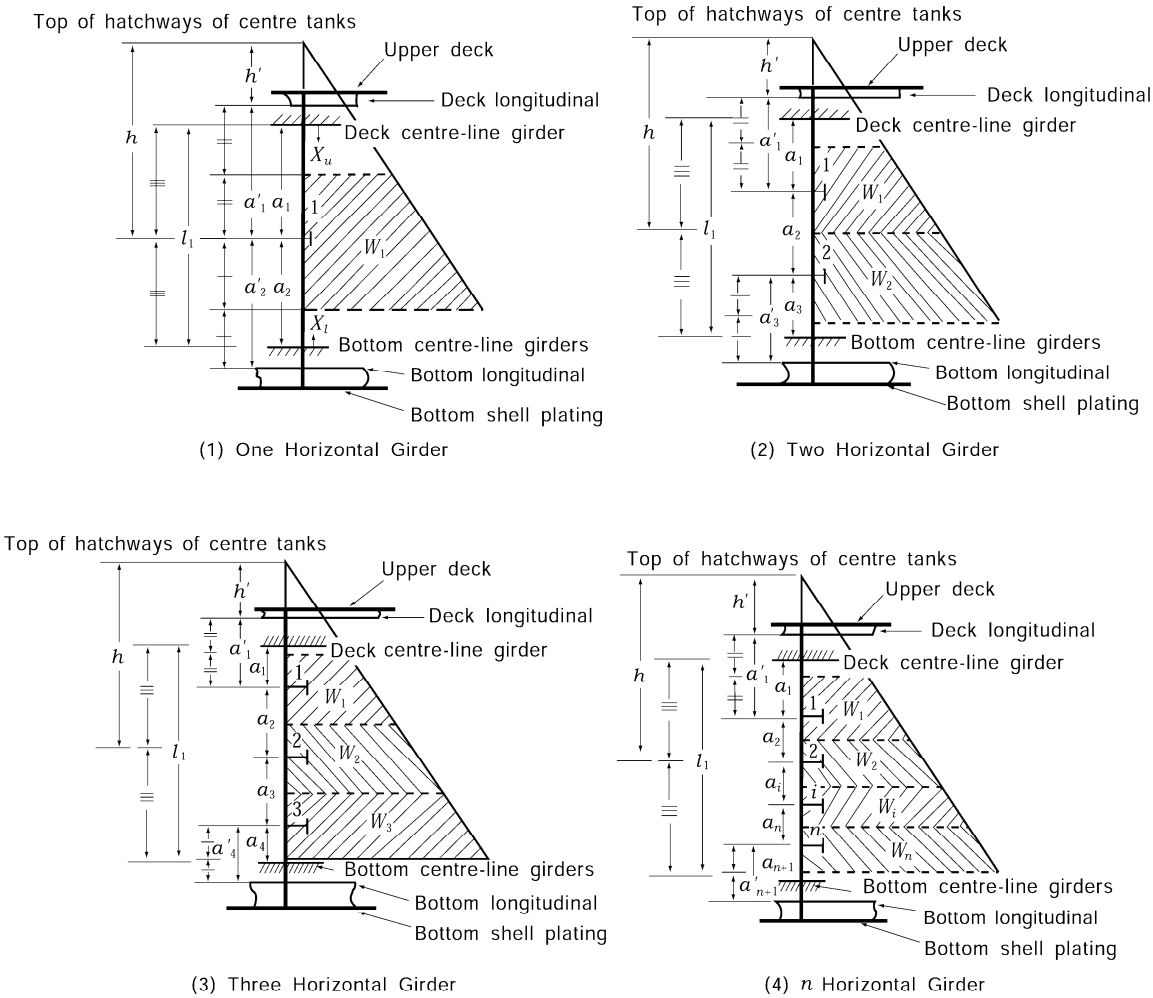


Fig 7.1.6 Measurement of each dimension and load

(2) In case where one horizontal girder is provided, the depth, web thickness and section modulus of strong vertical webs supporting the horizontal girder are not to be less than those obtained from the following formulae respectively:

Depth of webs : $d = 3\left(\frac{l_1}{B_0}\right)^2 d_0$ (mm)

Web thickness :

Web thickness of vertical webs in the portion between the top of face plates of bottom girders and the horizontal girders :

$$t_1 = \frac{87}{d_l - a} K\left[\frac{1}{4} B_0 h l_1 \left\{\frac{1}{2} - \frac{X_l}{l_1} + \frac{l_1}{2h}\left(\frac{1}{5} - \frac{X_l}{l_1} + \frac{X_l^2}{l_1^2}\right)\right\} + W_1\left(\frac{a_1}{l_1}\right)^2\left(1 + \frac{2a_2}{l_1}\right)\right] + 2.5 \quad \text{(mm)}$$

Web thickness of vertical webs in the portion between the lower surface of face plates of deck girders and the horizontal girders :

$$t_2 = \frac{87}{d_u - a} K\left[\frac{1}{4} B_0 h l_1 \left\{\frac{1}{2} - \frac{X_u}{l_1} - \frac{l_1}{2h}\left(\frac{1}{5} - \frac{X_u}{l_1} + \frac{X_u^2}{l_1^2}\right)\right\} + W_1\left(\frac{a_2}{l_1}\right)^2\left(1 + \frac{2a_1}{l_1}\right)\right] + 2.5 \quad \text{(mm)}$$

Section modulus of webs : $Z = 5.2Kk^2B_0hl_1^2 \quad (\mathrm{cm}^3)$

where :

X_l = distance measured upward from the top of face plates of bottom girders (m).

X_u = distance measured downward from the lower surface of face plates of deck girders (m).

$$W_1 = \frac{B_0}{8}(a'_1 + a'_2)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a'_2\right) \quad (\mathrm{t})$$

l_1, B_0, d_0, d_l, d_u, a_1, a_2, a_1', a'_2, h, h', k = as specified in (1) respectively.

a = depth of slot (m). Where, however, the slots are effectively covered by collar plates, a may be taken as zero.

505. Vertical webs supported by horizontal girders

Where vertical webs provided on transverse bulkhead are supported by the horizontal girders specified in **506.**, the depth, web thickness and section modulus of vertical webs are not to be less than those obtained from the following formulae respectively.

Depth of webs : $d = 143l \quad (\mathrm{mm})$ or $2.5a \quad (\mathrm{mm})$, whichever is the greater.

Web thickness : $t = C_1K\dfrac{Shl}{d_0 - a} + 2.5 \quad (\mathrm{mm})$

Section modulus of webs : $Z = C_2Kk^2Shl^2 \quad (\mathrm{cm}^3)$

where :

a = depth of slots (mm).

l = overall length between the points of support of vertical webs (m), which is equal to the distance from the inner surface of face plates of bottom girders to the horizontal girder just above it, that between the horizontal girders, or that from the inner surface of face plates of deck girders to the horizontal girders just below it.

S = spacing of vertical webs (m).

h = distance from the mid-point of l to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

d_0 = depth of webs at the point under consideration (mm).

k = correspondingly as specified in **Table 7.1.3.**

C_1, C_2 = coefficients given by the following formulae respectively:

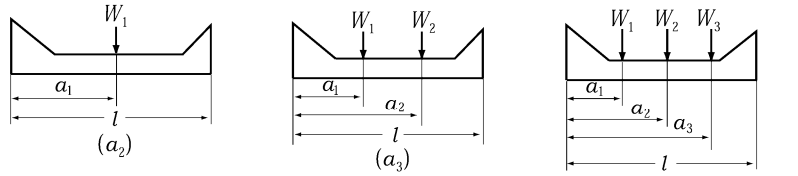
$$C_1 = 87\left\{\frac{1}{2} - \frac{X}{l} + \frac{1}{2}\,\frac{l}{h}\left(\frac{1}{5} - \frac{X}{l} + \frac{X^2}{l^2}\right)\right\},$$

$$C_2 = 8\left(1 + \frac{l}{10h}\right)$$

X = distance measured upward from the lower end of l (m).

506. Horizontal girders supporting vertical webs 【See Guidance】

Where vertical webs are supported by horizontal girders provided on transverse bulkheads, the depth, web thickness and section modulus of horizontal girders are not to be less than those obtained from the following formulae respectively. The section modulus, however, is not to be less than that obtained from the formulae taking the starting point of a_i each end of the girders, whichever is the greater. (See Fig **7.1.7**)



(1) One vertical web (2) Two vertical webs (3) Three vertical webs

Fig 7.1.7 Measurement of l, a_1, a_2, etc.

Depth of girders : $d = 143l$ (mm)

Web thickness in the portion between the ends of horizontal girders and the vertical webs at ends :

In case of one vertical web : $t_1 = \frac{87}{d_0} K W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + 2.5$ (mm)

In case of two vertical webs :

$$t_2 = \frac{87}{d_0} K \left[W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + W_2 \left(1 - \frac{a_2}{l}\right)^2 \left(1 + \frac{2a_2}{l}\right) \right] + 2.5 \quad \text{(mm)}$$

In case of three vertical webs :

$$t_3 = \frac{87}{d_0} K \left\{ W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + W_2 \left(1 - \frac{a_2}{l}\right)^2 \left(1 + \frac{2a_2}{l}\right) + W_3 \left(1 - \frac{a_3}{l}\right)^2 \left(1 + \frac{2a_3}{l}\right) \right\} + 2.5 \quad \text{(mm)}$$

Section modulus of girders :

In case of one vertical web : $Z_1 = 85.5 K k W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2$ (cm^3)

In case of two vertical webs : $Z_2 = 85.5 K k \left\{ W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2 + W_2 a_2 \left(1 - \frac{a_2}{l}\right)^2 \right\}$ (cm^3)

In case of three vertical webs :

$$Z_3 = 85.5 K k \left\{ W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2 + W_2 a_2 \left(1 - \frac{a_2}{l}\right)^2 + W_3 a_3 \left(1 - \frac{a_3}{l}\right)^2 \right\} \quad \text{(cm}^3\text{)}$$

where:

l = overall length between the points of support of horizontal girders (m), which is equal to the distance between side shell plating and longitudinal bulkhead or that between the longitudinal bulkheads (m). Where, however, side stringers and longitudinal girders on longitudinal bulkheads are provided, the distance between the face plates of longitudinal girders is to be taken as l and where the strong vertical webs specified in **504.** are provided in the middle between the longitudinal bulkheads, a half of the distance between the longitudinal bulkheads is to be taken as l.

W_i (i = 1,2,3) = load which horizontal girders receive from the vertical web of number i counting from the end of l, which is given by the following formulae :

$$W_1 = \frac{1}{2} a_2 b h \quad (\mathrm{t})$$

$$W_2 = \frac{1}{2} (a_3 - a_1) b h \quad (\mathrm{t})$$

$$W_3 = \frac{1}{2} (l - a_2) b h \quad (\mathrm{t})$$

b = width of the area to be supported by horizontal girders (m).

h = distance from the mid-point of b to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

a_i (i = 1,2,3) = distance from the end of l to the vertical web of number i counting from the end of l (m).

k = correspondingly as specified in **Table 7.1.3.**

507. Horizontal girders supporting vertical stiffeners

Where vertical stiffeners are supported by horizontal girders provided on transverse bulkheads, the depth, web thickness and section modulus of horizontal girders are not to be less than those obtained from the following formulae respectively :

Depth of girders : $d = 143\, l$ (mm) or $2.5\, a$ (mm), whichever is the greater.

Web thickness : $t = CK\dfrac{S h l}{d_1 - a} + 2.5 \quad (\mathrm{mm})$

Section modulus of girders : $Z = C' K k^2 S h l^2$

where :

a = depth of slots (mm).

l = overall length between points of support of horizontal girders (m), which is equal to the distance between side shell plating and longitudinal bulkhead or that between longitudinal bulkheads. Where, however, side stringers and longitudinal girders on longitudinal bulkhead are provided, the distance between the face plates of longitudinal girders is to be taken as l.

S = width of area to be supported by girders (m).

h = distance from the mid-point of S to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

d_1 = depth of girders at the point under consideration (mm).

k = correspondingly as specified in **Table 7.1.3.**

C = coefficient given by the following formula:

$$C = \left| 87\left(\frac{1}{2} - \frac{X}{l}\right) \right|$$

X = distance measured from the end of l (m).

C' = coefficient given in **Table 7.1.11.**

Table 7.1.11 Coefficient C'

	Where side stringers and vertical webs on longitudinal bulkheads are provided	Others
Wing tank	7	10
Centre tank	7	$10\frac{B_S}{B_C}$

NOTES:
B_S = width of wing tanks (m), Which is equal to the distance between side shell plating and longitudinal bulkhead.
B_C = width of centre tanks (m), which is equal to the distance between longitudinal bulkheads. Where, however, B_S/B_C exceed 1.0, B_S/B_C is to be taken as 1.0 and where less than 0.7, to be taken as 0.7.

508. Web plates, face plates and stiffeners of girders

1. The thickness of vertical webs and horizontal girders provided on transverse bulkheads is not to be less than that required by the following:
   (1) The web thickness of strong vertical webs specified in **504.** is to be as required in **405. 1** (1) in general. However, for the upper 2/3 of l_1, excluding the portion nearby the top of vertical arm of lower bracket of vertical webs, the formula may have its first term multiplied by 0.85.
   (2) The web thickness of those webs and girders specified in **505.** to **507.** is to be as required in **405. 1** (3) in general.
2. The thickness and breadth of face plates forming vertical webs and horizontal girders specified in **Par 1** is not to be of less scantlings than required in **401. 4.** However, the depth of girders of corrugated bulkheads is to be measured from the middle of the depth of corrugation.
3. The girders specified in **Par 1** are to be provided with flat bar stiffeners, applying the requirements of **405.**

509. Special stiffening of web plates and end connection brackets

As regards the strong vertical webs specified in **504.** the lower brackets and the web plates between the top of face plate of bottom girders and the horizontal girders situated directly above the bottom girders, including the web plates up to the horizontal girder situated directly above the said horizontal girder in case where the said girder is situated within 1/3 the length of vertical arm of brackets above face plate of bottom girders, are to be provided with stiffeners specially in close spacing. Regarding the horizontal girders specified in **506.** and **507.**, the end brackets and the web plates in the vicinity of the inner edge of brackets are also to be provided with stiffeners in close spacing. Further, a special consideration is to be given to the web plates at the portion specified above to be protected from buckling, in case where the said plates are unavoidably lap jointed.

510. Additional strengthening of bulkhead in large tanks

As for large tank boundaries, the scantlings of bulkhead plates, stiffeners, vertical and horizontal girders are not to be less than those obtained from relevant formulae in **501.** to **507.**, where the value of h or h' is the one specified in each requirement or that given by the following formula, whichever is the greater.

$$H = 0.85(h + \Delta h) \quad (\mathrm{m})$$

where:
h = h or h' as specified in each requirement.
Δh = as specified in **Pt 3, Ch 15,105.**

511. Swash bulkheads 【See Guidance】

1. Stiffeners and girders are to be of adequate strength in conformity with the size and opening ratio of tanks.

2. The sectional area of wash bulkhead plating to the depthwise direction of the ship in centre tanks is not to be less than that required in **501.** as far as practicable.

3. The thickness of bulkhead plating is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater. The thickness of the lowest strake of transverse wash bulkheads is to be properly increased.

$$t = 0.3\,S\sqrt{(L+150)K} + 2.5 \quad (\mathrm{mm})$$

where:

S = spacing of stiffeners (m).

4. The breadth and thickness of the uppermost and the lowest strakes in centre line wash bulkheads are to be as required in **502. 2** as far as practicable.

5. It is recommended that a special consideration be given to the thickness of wash bulkhead plating to prevent the plating from shear buckling.

Section 6 Relative Deformation of Wing Tanks

601. Relative deformation of wing tanks 【See Guidance】

As regards wing tanks, where the value obtained from the following formula exceeds 0.15, a special consideration is to be given to the structure of wing tanks.

$$\delta = \frac{h - 0.32\,d}{n_b K_b + n_s \eta_s K_S + n_t \eta_t K_t} \times \frac{a}{b} l$$

where:

a = half-breadth of centre tanks (m).

b = breadth of wing tanks (m).

h = distance from the top of keel to the top of hatches of centre tanks (m).

l = length of one tank situated between oil-and/or water-tight bulkheads in centre tanks (m).

n_b, n_s, n_t = number of transverse bulkheads, wash bulkheads and transverse rings in wing tanks located within l, respectively. The bulkheads at the fore and aft ends of l are to be counted 1/2, respectively.

η_s, η_t = values given in **Table 7.1.12** in accordance with the opening ratio. For intermediate value of opening ratio, η_s and η_t are to be obtained by linear interpolation.

Table 7.1.12 Coefficients η_s and η_t

Opening ratio (%)	η_s and η_t
0	1.00
5	0.95
10	0.80
20	0.55
30	0.35
40	0.23
50	0.15
60	0.10
70	0.06

K_b, K_s, K_t = values obtained from the following formula : $81.0\dfrac{Dt}{\alpha b}$ $(\mathrm{t/cm})$

where:

t = mean thickness of transverse bulkhead plating in wing tanks (mm), in obtaining K_b value.
mean thickness of wash bulkhead plating in wing tanks (mm), in obtaining K_s value.
mean thickness of transverse rings in wing tanks (mm), in obtaining K_t value.

α = value obtained from the following formulae, in case where transverse bulkheads or wash bulkheads in wing tanks are of corrugated form, in accordance with the case where the corrugation is vertical or horizontal:

For vertical corrugation : $\dfrac{Girth\ \ length\ \ of\ \ ship\ \ in\ \ athwartships\ \ (\mathrm{m})}{b}$

For horizontal corrugation : $\dfrac{Girth\ \ length\ \ of\ \ ship\ \ in\ \ depthwise\ \ (\mathrm{m})}{D}$

For the case other than above, the value is to be 1.0.

Section 7 Welding

701. Welding

1. The welding in tankers is to be in accordance with the requirements given in **Pt 3, Ch 1, Table 3.1.11** except where specially prescribed in this Article for cargo oil tanks.
2. The application of the fillet welding is to be as given in **Table 7.1.13.**

Table 7.1.13 Fillet welding

Column	Item		Where applied	Kind of weld
1	Transverse girders and webs	Web plates	Shell, deck or longitudinal bulkhead plating	*F*1
2			Web plates	*F*1
3			Face plates	*F*2
4		Slots in web plates	Web plates longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	*F*2
5		Tripping brackets and stiffeners provided on web plates	Web plates	*F*3
6			Web plates of longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	*F*1
7	Longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads		Shell, deck or longitudinal bulkhead plating	*F*3
8	Cross ties		Members forming cross ties (web plates to face plates)	*F*3
9			Face plates of transverses, side stringers or longitudinal girders	*F*1
NOTE: Where the radius at the toe of end brackets is small, it is recommended that *F*1 be used for appropriate length at the toe of bracket.				

Section 8 Supplementary Provisions for Tankers Having Longitudinal Bulkhead at Centre Line Only

801. Application

The requirements specified hereunder apply to tankers not exceeding 120 m in length having longitudinal bulkhead at the centre line only. As regards the matters not specially provided in these requirements, the requirements in each previous Articles concerned are to be applied. Application of **406.** and **509.,** however, may be dispensed with.

802. Trunks

1. The thickness of trunk top and side plating is not to be less than that obtained from the following formula :

$$t = 6.5\frac{S}{\sqrt{K}} + 2.0 \quad (\mathrm{mm})$$

where:

S = spacing of longitudinal stiffeners (m).

2. The section modulus of longitudinal stiffeners provided on trunks is not to be less than that obtained from the following formula :

$$Z = 2K\sqrt{L}Sl^2 \quad (\mathrm{cm}^3)$$

where:

l = spacing of transverses (m).

S = spacing of longitudinal stiffeners (m).

803. Transverses in cargo oil spaces

1. Transverses in cargo oil spaces are to be in accordance with the requirements of **401.** to **406.** except those specially specified in this Article. In small ships, however, the brackets at ends of transverses may be dispensed with, subject to the approval by the Society.

2. The depth and section modulus of bottom transverses are not to be less than those obtained from the following formulae respectively :

Depth of transverses : $d = 0.16 l_0 \quad (\mathrm{m})$

Section modulus of transverses : $Z = 9.7Kk^2(d + 0.026L')Sl_0^2 \quad (\mathrm{cm}^3)$

where:

l_0 = overall length of transverses (m), which is equal to the distance from the inner surface of face plates of side transverses to the inner surface of face plates of vertical webs on centre line bulkhead.

S = spacing of transverses (m).

k = correspondingly as specified in **Table 7.1.3.**

3. The depth and section modulus of side transverses are not to be less than those obtained from the following formulae respectively. Where the transverses are of tapered from, the requirements in **403. 1** (2) are to be applied.

Depth of transverses : $d = 0.15 l_0 \quad (\mathrm{m})$

Section modulus of transverses : $Z = 8.7Kk^2Sh\,l_0^2 \quad (\mathrm{cm}^3)$

where:

l_0 = overall length of side transverses (m), which is equal to the distance between the inner surfaces of face plates of bottom transverses and deck transverses. (See Fig **7.1.3**)

S = spacing of transverses (m).

h = distance from the mid-point of l0 to the point high as given by the following formula above the top of keel (m):

$h = d + 0.038L \quad (\mathrm{m})$

k = correspondingly as specified in **Table 7.1.3.**

4. The section modulus of transverses at bilge is not to be less than that obtained from the following formula. However, in calculating the section modulus of transverses, the neutral axis of section is to be assumed as to situate at the mid-point of the depth of transverses d_b. (See Fig **7.1.3**)

$$Z = 7.8KSh l_0^2 \quad (\mathrm{cm}^3)$$

where:

S, h, l_0 = as specified in **Par 3** respectively.

5. **Deck transverses**

(1) The depth and section modulus of deck transverses in ships having no trunk are not to be less than those determined correspondingly in accordance with the requirements in **402. 2** (1).

(2) In trunk ships, it is a standard arrangement that transverses extending from side to side of the ship across the trunk are provided In this case, the depth of deck transverses regarded as being supported by trunks may be $0.03B$.

6. As for vertical webs provided on the centre line bulkhead, the requirements in **Par 3** for side transverses are to be correspondingly applied, but the depth and section modulus of deck transverses are not to be less than those obtained from the formulae with each coefficient multiplied by 0.8 respectively.

804. Stiffening transverse

Trunks are to be provided with stiffening transverses in line with the deck transverses. The section modulus of stiffening transverses is not to be less than that obtained from the following formula :

$$Z = 1.4K\sqrt{L}Sl^2 \quad (\mathrm{cm}^3)$$

where:

l = half-breadth of trunks (m)

S = spacing of stiffening transverses (m)

Section 9 Special Requirements for Wing Tanks at Fore Parts

901. Application

In case of oil tankers of 200 m and over in length, the members provided in wing tanks not being ballasted at full load condition which are located between $0.15L$ from the bow and the collision bulkhead are to comply with the requirements specified hereunder as well as the requirements in each previous Articles concerned.

902. Side longitudinal frames

1. The section modulus of side longitudinal frames is not to be less than that obtained from the following formula :

$$Z = 9KSh l^2 \quad (\mathrm{cm}^3)$$

where:

l = spacing of transverses (m).

S = spacing of longitudinal frames (m).

h = distance measured from the frame concerned to the point of the height which is to be obtained from the following formula above the top of keel : $h' = 0.7d + 0.05L$ (m)

In any case, however, the distance is not to be less than that obtained from the following formula : $h = 0.2\sqrt{L} + 0.03L$ (m)

2. Where side longitudinal frames are connected to transverse by brackets, the section modulus may be taken as the value obtained from the formula in the preceding Paragraph multiplied by the fol-

lowing factor :

Where C is obtained from the following formulae : $(1-C)^2$

In case where brackets are provided at both ends : $C=\frac{b_1+b_2-0.3}{l}$

In case where a bracket is provided at one end : $C=\frac{b-0.15}{l}$

b, b_1, b_2 = arm length of brackets on longitudinal frames respectively (m). In case, C is negative, C is to be taken as zero. (See Fig **7.1.8**)

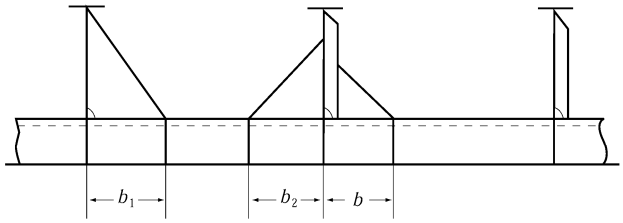


Fig. 7.1.8 Measurement of b, b_1 and b_2

903. Side transverses

1. The section modulus of side transverses is to be in accordance with the requirement in **403. 1** (5). In applying the formula, however, h is the distance from the mid-point of l_0 to $0.1L$ above the top of keel (m).

2. The thickness of webs of side transverses at inner edge of brackets at lower ends is to be in accordance with the requirements in **403. 1** (3). In applying the formula, however, h is the distance from the midpoint of l_0 to $0.1L$ above the top of keel (m).

3. The thickness of webs between cross ties is not to be less than that obtained from the following formula :

$$t=43.5\,CK\frac{Sh_il_i}{d_i-a_i}+2.5 \quad (\mathrm{mm})$$

where:

S = spacing of transverses (m).

d_i = depth of web at the mid-point of each span (mm).

a_i = maximum depth of slots in each span (mm). The depth, however, may be taken as zero where the slots are provided with collar plates.

l_i = span of each transverse (m). However, for the part between cross ties and bottom or deck transverses. l_i is the distance between the centre of cross ties and the face plate of bottom or deck transverses; for the part between cross ties, the distance between centres of cross ties. (See Fig **7.1.9**)

h_i = distance from the mid-point of each l_i to the point $0.1L$ above the top of keel. Where, however, the distance is less than $0.06L$ (m), h_i is to be taken as $0.06L$ (m).

C = coefficient given by the following formula :

$$C=1.2-\frac{2b_i-0.3}{l_i}$$

b_i = arm length of brackets at both ends of span, whichever is the smaller (m). (See Fig **7.1.9**)

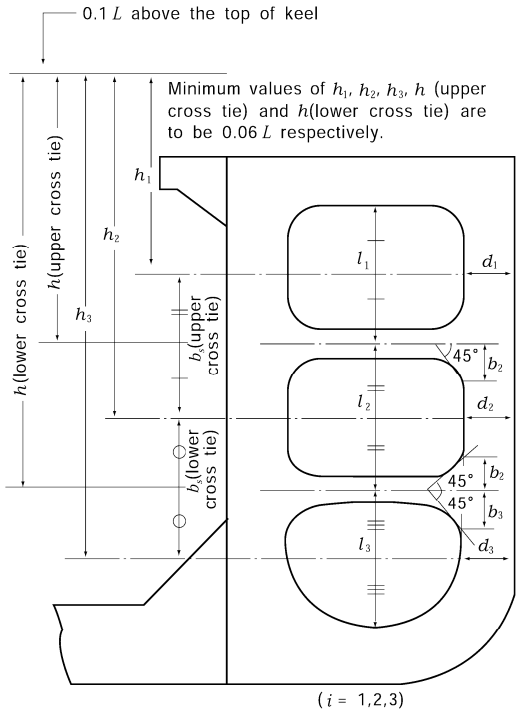


Fig. 7.1.9 Measurement of l, b, etc.

4. The thickness of web at the portion where cross ties are connected is to be as required in **403. 1** (4). In applying the formula, however, h is the distance from the mid-point of b_s to the point 0.1 L above the top of keel (m), except that h is to be taken as 0.06L (m) where the distance is less than 0.06L (m).

904. Special stiffening of web plates at ends of transverses

The upper and lower end brackets connected to side transverses and vertical webs on longitudinal bulkheads, and the web plates of transverses at the inner edge of the brackets and in the vicinity of the portion where cross ties are connected, are to be provided with stiffeners in specially close spacing.

905. Cross ties

The cross sectional area of cross ties and web thickness are to be in accordance with the requirements in **404.** In applying the formula, however, h is the distance from the mid-point of b_s to the point 0.1L above the top of keel (m), except that h is to be taken as 0.06 L (m), where the distance is less than 0.06L (m).

906. Vertical webs on longitudinal bulkheads

The scantlings of vertical webs on longitudinal bulkheads are not to be less than generally those determined in accordance with the requirements for side transverses.

Section 10 Piping Systems and Venting Systems for Oil Tankers

1001. General 【See Guidance】

1. Application

(1) The requirements in this Section apply to the piping systems and venting systems for ships in-

tended to be registered as oil tankers.

(2) The requirements in this Section apply to oil tankers which have all the following features. The piping systems and venting systems for other types of oil tankers will be considered by the Society in each case.
  (a) Tankers carrying crude oil, petroleum products having a flash point not exceeding 60°C (closed cup test) or other similar liquid cargoes
  (b) Tankers of which the machinery spaces and cargo oil tanks (including slop tanks, the same being referred hereinafter in this Section) are arranged in accordance with the requirements in **Pt 8, Ch 2, Sec 4.**
  (c) Tankers of which the cargoes are loaded by land facilities and unloaded by cargo pumps on board ship.

(3) In addition to the requirements in this section, the requirements in **Pt 8, Ch 2, Sec 4.** and **Pt 8, Ch 9, Sec 5.** are to be complied with.

2. Drawings and Data

Drawings and data to be submitted are generally as follows.

(1) Drawings and data for approval (with materials, dimensions, design pressures, etc. of pipes, valves, etc. and the arrangement of devices to prevent the passage of flame)
  (a) Piping diagram of cargo oil pipes and instrumentation
  (b) General arrangement of bilge systems and ventilation systems of a cargo oil pump room
  (c) General arrangement of venting systems for cargo vapours, etc.
  (d) Other drawings and data considered necessary by the Society

(2) Drawings and data for reference
  (a) Capacity calculation sheet for pressure/ vacuum valves and overpressure protective device of cargo oil tanks
  (b) Other drawings and data considered necessary by the Society

3. Special type

Where ships are equipped with new types of pumps and/or piping systems, specifications and detailed drawings are to be submitted to the Society for approval. The Society may require additional detailed investigations or tests of their own, where deemed necessary by the Society.

4. In application of the **1001. 3,** "Requirements concerning use of crude oil or slops as fuel for tanker boilers" are to comply with **Annex 7-1「Additional Requirements for Oil Tankers Using Crude Oil as a Fuel for Boilers」.** *(2021)*

1002. Cargo oil pumps and piping systems

1. Cargo oil pumps

(1) Cargo oil pumps are to comply with the following (a) to (e).
  (a) Each pump is to be so designed as to minimize the risk of sparking and oil leakage at the seal.
  (b) Where machinery is driven by shafting passing through a bulkhead or deck, shafting is to be provided with flexible couplings, and gastight seals with efficient lubrication or other means of ensuring the permanence of the gastight seal are to be fitted in way of the bulkhead or deck. If a bellows piece is incorporated in the design, it is to be pressure tested before fitting. The gastight seals or other means are to be so designed as to minimize the risk of sparking, and the sealing parts contacted with the shafting are to be material that will not initiate sparks. **【See Guidance】**
  (c) Cargo oil pumps are to comply with the requirements in **Pt 8, Ch 2, 410. 1**.
  (d) A stop valve is to be provided on the delivery side of the pump. However, such stop valve may be omitted, provided that the cargo oil pipe on the delivery side of the pump is provided with a stop valve in a proper position.
  (e) Where a relief valve is provided on the delivery side of the pump, the arrangement is to be such that the escaped oil is led to the suction side of the pump.
  (f) A pressure measuring device is to be fitted on the delivery side of each pump. Where the pump is driven by a prime mover which is installed in the space other than the pump room, an additional pressure measuring device is to be fitted at a suitable position visible from the controlling position.

(2) Where prime movers, other than steam engines or hydraulic motors, for driving the cargo oil pumps are installed in the cargo oil pump room, descriptions and construction of the prime movers and the driving system are to be submitted for the approval by the Society.
(3) Where deep well pumps, submerged pumps, etc. are installed, construction of the pumps and driving systems are to be submitted for approval by the Society.
(4) In general, cargo oil pumps are not to be used for other purposes than transferring cargo oil or ballast in cargo oil tanks, transferring tank cleaning water for cargo oil tanks, discharging bilge as specified in **1003. 1**(2), or discharging ballast as specified in **1003. 2** (2).

2. Arrangement of cargo oil piping systems

(1) Cargo oil pipes are classified into Class Ⅲ, except where considered necessary by the Society.
(2) Each cargo oil tank is to be provided with a cargo oil suction pipe(s) so arranged that cargo unloading can be carried out with one of the cargo oil pumps out of use.
(3) Cargo oil pipes are to be so arranged as to be capable of loading cargo oil to cargo oil tanks without passing through cargo oil pumps. Where loading pipes are led directly to the tanks from above the deck, the opening ends of these pipe are to be led to the lower part of the tanks as far as practicable to prevent the accident caused by the generation of static electricity.
(4) Where sea suction pipes for ballasting purpose are connected to cargo oil pipes, stop valves are to be provided between the sea suction valves and the cargo piping.
(5) Slip joints used in the cargo oil pipes are to be in compliance with **Pt 5, Ch 6, 104. 5.**
(6) Sea suction pipes and discharge pipes for permanent ballast tanks are not to be connected to the sea suction pipes and discharge pipes for cargo oil tanks.

3. Alternative use of tanks

Where cargo oil tanks are so designed that they can also be used as ballast tanks or fuel oil tanks, the tanks are to be provided with devices which the Society requires, and approved drawings or documents having descriptions on a detailed operating manual for the alternative use are to be provided on board the ship. **【See Guidance】**

4. Separation of cargo oil pumps and cargo oil pipes 【See Guidance】

(1) Cargo oil pipes are to be entirely separated from other pipes, except where permitted in **1002. 2** (2) and **1003. 1** and **2.**
(2) Cargo oil pipes are not to be led through fuel oil tanks nor engine room and accommodation spaces where sources of vapour ignition are normally present. In addition, these pipes are not to be led to spaces forward the collision bulkhead or after the front bulkhead of the engine room.
(3) Cargo oil pipes on the weather deck are to be arranged sufficiently apart from the accommodation spaces.
(4) Where a ship is equipped with bow and/or stern loading and unloading of cargo oil outside the cargo area, the connections of the cargo lines leading to the cargo hose connection therein are to be of welded joints except valve connections and the cargo lines are to be clearly identified and segregated by following means of (A) or (B) situated in the cargo area. The open ends of the cargo lines are to be provided with a blank flange at the bow and/or stern end connections.
  (A) Two valves which can be secured in the closed position and provided that the efficiency of the segregation can be checked
  (B) One valve together with another closing appliances providing an equivalent standard of segregation such as a removable spool piece or spectacle flange
(5) Cargo oil pipes and similar pipes to cargo oil tanks are not to pass through ballast tanks. However, these pipes may pass through the ballast tanks provided that these pipes in ballast tanks are of short length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.
(6) Notwithstanding preceeding (5), for oil tankers other than double hull tankers, cargo oil pipes may pass through the ballast tanks provided that the connections of these pipes are of welded joints or flanged joints which have no risk of leakage. Expansion bends only, not glands, are permitted in these lines within ballast tanks.

5. Bulkhead valves of cargo oil piping systems 【See Guidance】

(1) Cargo oil pipes passing through oiltight bulkheads between cargo oil tanks and pump rooms are to be provided with stop valves as close to the bulkhead as practicable.
(2) Where the valves prescribed in (1) are located inside the pump room, they are to be made of steel or cast iron products with an elongation of 12 % and above. These values are to be capa-

ble of being closed at the position of the valves and from a readily accessible position outside the compartment in which they are located. However, if the valves operated at a position above the deck are fitted on each cargo oil branch pipe, the valves located inside the pump room may be of cast iron products with an elongation of less than 12 % without remote control device.

(3) Where the valves prescribed in (1) are located inside the tank, the valves may be of cast iron and need not be capable of being closed at the position of the valves, but they are to be provided with remote control devices, and the pipes are to be provided with another valve in the pump room.

(4) Where the valves are required to be remote controlled according to the requirements in (2) and (3), means are to be provided to show whether they are open or closed.

6. Valve operation rod penetrating through decks

Stuffing boxes are to be provided at positions at which operating rods from cargo valves pass through gastight or oiltight decks.

7. Piping in cargo oil tanks 【See Guidance】

(1) Pipes other than cargo oil pipes, cargo oil heating pipes, ballast pipes of cargo tanks and pipes permitted in (2) to (4) are not to pass through cargo oil tanks nor to have any connection to these spaces.

(2) Pipes for remote control of cargo oil piping systems, and vapour discharge pipes, tank cleaning pipes and sounding devices of cargo oil tanks may be led to cargo oil tanks.

(3) Scupper pipes, sanitary pipes, etc. may be led through cargo oil tanks subject to the approval by the Society.

(4) Ballast pipes and other pipes such as sounding and vent pipes to ballast tanks are not to pass through cargo oil tanks. However, these pipes may pass through the cargo oil tanks provided that these pipes in cargo oil tanks are of short length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.

(5) Notwithstanding preceeding (4), for oil tankers other than double hull tankers, ballast pipes of ballast tanks adjacent to a cargo oil tanks may pass through cargo oil tanks provided that the connections of these pipes are of welded joints or flanged joints which have no risk of leakage. Expansion bends only, not glands, are permitted in these lines within cargo oil tanks.

8. Sounding devices of cargo oil tanks 【See Guidance】

A suitable sounding device approved by the Society is to be fitted onto any cargo oil tank. The sounding device is to be designed or arranged to prevent any outflow of flammable gases into spaces such as engine room, accommodation spaces, etc. where sources of vapour ignition are normally present.

9. Steam pipes

(1) The cargo oil heating steam supply and return pipes are not to penetrate the cargo oil tank plating, other than at the top of the tank, and the main supply pipes are to be run above the weather deck.

(2) Isolating shut-off valves or cocks are to be provided at the inlet and outlet connections to the heating circuit(s) of each tank.

(3) The cargo oil heating steam return pipes are to be led to an observation tank or other oil detectors in a position well-ventilated and well-lighted part of the space as apart as possible from hot surfaces such as boilers and ignition sources for the detection of contaminated oil in steam drain.

(4) The steam temperature in steam pipes arranged in cargo oil pump rooms and cargo oil heating steam pipes is not to exceed 220℃.

(5) In the cargo oil pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the bilge wells.

(6) Each branch connection of cleaning steam pipes of cargo oil tanks or other tanks to which a cargo oil pipe is led is to be provided with a screw-down non-return valve or two stop valves.

10. Thermal oil pipes

(1) The thermal oil piping arrangement for the cargo oil tanks is to comply with following requirements:

(A) All joints in the cargo oil tanks are to be of welded type. *(2018)*

(B) Isolating shut-off valves or cocks are to be provided at the inlet and outlet connections to

the cargo oil tanks. Where the thermal oil pipe penetrates the oiltight bulkhead between a cargo oil tank and the pump room, shut-off valves or cocks may be installed as close to the bulkhead as practicable.

(C) The system is to be so arranged that the pressure in the coil is at least 3 m water head above the static head of the cargo when the circulating pump is not operating.

(D) For the ships only carrying oils having a flash point not exceeding 60 ℃, the requirement in **Pt 5, Ch 6, 1004.** is to be applied.

(2) The thermal oil temperature in the cargo area is not to exceed 220 ℃.

11. Heating plants for asphalts cargo

(1) Heating plants for asphalt tanks are to be arranged.

(2) Heating coils in asphalt tanks are to be sufficient thickness with fully welded joint.

(3) Pumps and valve systems are to be suitable for the type of cargo to be transported.

(4) Heating system for cargo pumps and cargo lines is to be arranged.

(5) Temperature gauges are to be arranged in each cargo tanks enabling the recording of temperatures at bottom, midway between bottom and deck and at deck level in order to prevent overheating of cargo.

12. Integrated cargo oil and ballast driving systems

Emergency stopping devices and control systems of integrated hydraulic and/or electric system used to drive both cargo oil and ballast pumps including active control and safety systems(hereinafter referred to as「integrated cargo oil and ballast driving system」) are to comply with following requirements.

(1) Emergency stopping devices of integrated cargo oil and ballast driving system are to be independent from control systems. A single failure in the emergency stopping devices or the control systems is not to render the integrated cargo oil and ballast driving system inoperative.

(2) Manual emergency stops of cargo oil pumps are to be arranged in a way that they are not to cause the stop of the hydraulic power source.

(3) The control systems are to be provided with backup power supply, which may be satisfied by a duplicate power supply from the main switch board.
The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.

(4) Manual overriding or redundant arrangements are to be provided within the control systems to be made available for the operation of the integrated cargo oil and ballast driving system in the event of failure of the automatic or remote control systems.

1003. Piping systems for cargo oil pump rooms, cofferdams and tanks adjacent to cargo oil tanks

1. Bilge piping systems, etc. for cargo oil pump rooms and cofferdams adjacent to cargo oil tanks

(1) Bilge piping system consisting of a power driven pump or eductor is to be provided to discharge bilge in the cargo oil pump room and cofferdams adjacent to a cargo oil tank. The bilge in these spaces is not to be led to the engine room.

(2) Cargo oil pumps may be used for bilge drainage purpose specified in (1), provided that each bilge suction is provided with a screw-down non-return valve, and a stop valve or cock is fitted on the suction side of the pump and, in addition, a stop valve is fitted between the cargo oil pipe and the overboard discharge valve.

(3) Bilge pipes for a cofferdam adjacent to a cargo oil tank are to be entirely separate from those for spaces not adjacent to a cargo oil tank. However, a common bilge pump (except cargo oil pump) may be used for bilge drainage purpose of these spaces subject to the approval by the Society, provided that the bilge pipe for spaces not adjacent to a cargo oil tank has a non-return valve.

(4) Sounding pipes of cofferdams adjacent to a cargo oil tank is not to be less than 38 mm in internal diameter and unless otherwise approved by the Society to be led to above the weather deck. **【See Guidance】**

(5) The bilge system serving the cargo oil pump room is to be operable from outside the cargo oil pump room.

(6) Intrinsically safe type bilge level alarm devices are to be provided in the bilge well of the cargo oil pump room so as to activate an audible and visible alarm in the cargo control room and on the navigation bridge.

(7) The cargo oil pump room is to comply with the requirements in **Pt 8, Ch 2, 410. 3**.

2. Ballast tanks adjacent to cargo oil tanks

(1) The requirements in this Paragraph are also applied to ballast tanks used as cofferdams at the fore and after ends of cargo oil tanks in accordance with the requirements in **103. 4.**

(2) Ballast pipes of ballast tanks adjacent to a cargo oil tank are to be separated from other pipes and are not to be led to the engine room. For this purpose, an exclusive pump for ballasting and deballasting these tanks is, generally, to be provided in the pump room. However, where specially approved by the Society, the cargo pumps may be used for the purpose of only de-ballasting in an emergency. In case ballast tanks are not adjacent to cargo oil tank and qualified as being safe, other requirements by the Society will be applied. **【See Guidance】**

(3) Each air pipe to ballast tanks adjacent to a cargo oil tank is to be provided with an easily renewable flame screen at their outlets. In case where approved by the Society, the requirement in **Pt 5, Ch 6, 201. 4** (1) for the dimension of the air pipes will be properly modified. **【See Guidance】**

(4) Sounding pipes of ballast tanks adjacent to a cargo oil tank are to be led to above the weather deck, unless otherwise approved by the Society. **【See Guidance】**

3. Fore peak ballast tank

The fore peak ballast tank ballasted with the system serving other ballast tanks within the cargo area are to be meet the following requirements:

(1) The vent pipe openings are to be located on open deck at the suitable distance regarding following from sources of ignition.

(A) Areas on open deck or semi-enclosed spaces on open deck, within a sphere of 1.5 m radius from the vent pipe openings of fore peak ballast tank : zone 1

(B) Areas on open deck or semi-enclosed spaces on open deck, within 1.5 m surrounding the areas specified in the above (A) : zone 2

(2) Means are to be provided on the open deck to allow measurement of flammable gas concentrations within the fore peak tank by a suitable portable instrument.

(3) The sounding arrangement to the fore peak tank is to be direct from open deck.

(4) The access to the fore peak tank is to be direct from open deck. Alternatively, indirect access from the open deck to the fore peak tank through an enclosed space may be accepted provided that :

(A) In case the enclosed space is separated from cargo tanks by cofferdams, the access is to be through a gas tight bolted manhole located in the enclosed space and a warning sign is to be provided at the manhole stating that the fore peak tank may only be opened after;

(a) it has been proven to be gas free; or

(b) any electrical equipment which is not certified safe in the enclosed space is isolated.

(B) In case the enclosed space has a common boundary with the cargo tanks and is therefore hazardous, the enclosed space is to be well ventilated.

4. Fuel oil tanks adjacent to cargo oil tanks

Sounding pipes of fuel oil tanks adjacent to a cargo oil tank are to be led to above the weather deck, unless otherwise approved by the Society. **【See Guidance】**

5. Pump arrangement for forward compartment

A pump used for bilge drainage or transfer of ballast water or fuel oil in a compartment forward of the cargo oil tanks is to be exclusive and unless otherwise approved by the Society to be installed in the forward part of the ship. However, where approved by the Society, other suitable pumps than specified above may be used for the bilge drainage or transfer of ballast water in a compartment forward of the cargo oil tanks.

1004. Ventilation systems in cargo oil pump rooms

1. The capacity, structure and etc. of ventilation systems are to comply with the requirements in **Pt 8, Ch 2, 404. 1**.

2. The ducts are to be arranged, to permit ventilation from the vicinity of the pump room bilge, above the transverse floor plate or bottom longitudinals. An emergency intake located nearly 2 m above the pump room lower grating is to be arranged to the ducts, and this emergency intake is to have a

damper which is capable of being opened or closed from the weather deck and lower grating level.

3. The foregoing exhaust system is to be in association with open grating floor plates to allow the free flow of air.

1005. Venting systems of cofferdams adjacent to cargo oil tanks【See Guidance】

Effective venting systems are to be provided to cofferdams adjacent to a cargo oil tank. Where air pipes are provided for this purpose, each air pipe is to be provided with an easily renewable flame screen at their outlets, and they are not to be less than 50 mm in internal diameter. Where ventilation system is provided, the construction of the ventilation fan and the wire mesh screens fitted on the exhaust ducts are to comply with the requirements in **1004.** Air holes are to be cut in every part of the structure where there might be a change of gases being pocketed.

1006. Positions of openings of machinery spaces, deck houses, etc. and electrical equipment, etc.【See Guidance】

The arrangement of ventilation inlets and outlets and other deckhouse and superstructure boundary space openings is to be such as to complement the requirements in **Pt 8, Ch 2, 403.** Such vents especially for machinery spaces are to be situated as far aft as practicable. Due consideration in this regard is to be given when the ship is equipped to load or discharge at the stern. Sources of ignition such as electrical equipment are to be so arranged as to avoid an explosion hazard.

1007. Tankers carrying only oils having a flash point exceeding 60 °C

For tankers intended only for the carriage of oils having a flash point exceeding 60 ℃ the requirements in this Section applies as follows;

1. The requirements in **1001. 2** to **1002. 9, 1003. 1** (3) to (7), **1003. 2** (1), **1003. 3** & **5, 1005.** to **1006.** may be properly modified.
2. The requirements in **1002. 11, 12** & **1003. 1** (2) are to be satisfied.
3. Bilges of the cargo oil pump room and cofferdams adjacent to a cargo oil tank may be led to the engine room (See **1003. 2** (1)).
4. Ballast pipes of ballast tanks adjacent to a cargo oil tank may be led to the engine room (See **1003. 2** (2)). The wire gauze to prevent the passage of flame required for the outlets of the air pipes to the ballast tanks may be omitted (See **1003. 2** (3)). The sounding pipes of these tanks may be arranged to have openings below the weather deck (See **1003. 2** (4)).
5. The sounding pipes of fuel oil tanks adjacent to a cargo oil tank may not be led to above the weather deck (See **1003. 4**).
6. The requirements in **1004.** are to be satisfied. However, The capacity and structure of fan are to be in accordance with the guidance considered by the Society. **【See Guidance】**

1008. Testing and inspection

After the manufacture of piping systems and ventilating systems of oil carriers, the following tests are to be conducted in addition to the requirements in **Pt 5, Ch 6, Sec 14.**

1. **Tests on board**
   (1) Cargo oil pipes, after the completion of their piping, are to be subjected to a leak test at a pressure of 1.5 times the design pressure or greater.
   (2) Heating pipes inside cargo oil tanks are to be subjected to a leak test at a pressure of 1.5 times the design pressure or greater.
2. **After installation inboard, auxiliaries and piping systems are to be subjected to the following tests :**
   (1) A test on the functioning of cargo oil pumps.
   (2) A test on the functioning of ventilating systems.
   (3) A test on the functioning of various systems concerning safety measures specified in this Section.

Section 11 Electrical Equipment

1101. General【See Guidance】

1. Application

Electrical equipment for ships carrying crude oil, petroleum products or other similar liquid cargoes is to comply with the requirements in this Section, (KS C) IEC 60092-502 and all applicable requirements in **Pt 6, Ch 1.**

2. Dangerous spaces

(1) In tankers carrying flammable liquids having a flash point not exceeding 60°C(closed cup test), the following spaces and zones are to be considered as dangerous spaces.

(A) Zone 0

(a) Cargo tanks
(b) Slop tanks
(c) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks
(d) Interior of cargo pipes

(B) Zone 1

(a) Void spaces adjacent to integral cargo tanks
(b) Hold spaces containing independent cargo tanks
(c) Cofferdams and segregated ballast tanks adjacent to cargo tanks
(d) Cargo pump rooms
(e) Enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo tank bulkheads
(f) Spaces, other than cofferdam, adjacent to and below the top of a cargo tank(for example, trunks, passageways and hold)
(g) Areas on open deck or semi-enclosed spaces on open deck, within a sphere of 3m radius from cargo tank openings, gas or vapour outlets(for example, cargo tank hatches, sight ports, tank cleaning openings, sounding pipe openings, etc., the same being referred hereinafter), cargo manifold valve, cargo valve, cargo pipe flange and cargo pump-room ventilation outlets and any cargo tank vent outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variation
(h) Areas on open deck or semi-enclosed spaces on open deck, within a vertical cylinder of unlimited height and 6m radius from the cargo tank vent outlet centre, and within a hemisphere of 6m radius below the outlet which permits the flow of large volumes of gas or vapour during loading, discharging or ballasting
(i) Areas on open deck or semi-enclosed spaces on open deck, within 1.5 m from cargo pump room entrances, within a sphere of 1.5 m radius from of cargo pump room ventilation inlet and openings into cofferdams or openings specified (B) Zone 1
(j) Areas on open deck within spillage coamings surrounding cargo manifold valves and 3m beyond these, up to a height of 2.4m above the deck
(k) Areas on open deck over all cargo tanks(including all ballast tanks within the cargo tank block) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3m fore and aft on open deck, up to a height of 2.4m above the deck
(l) Compartments for cargo hoses
(m) Enclosed or semi-enclosed spaces in which pipes containing cargoes are located

(C) Zone 2

(a) Areas on open deck or semi-enclosed spaces on open deck, within 1.5m surrounding the areas specified in (B). But, within 2.0m for "any cargo tank vent outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variation" in (B) (g)
(b) Spaces within 4m surrounding the areas specified in (B) (h)
(c) Spaces forming an air-lock between the areas specified in (B) and non-hazardous areas
(d) Areas on open deck within spillage coamings intended to keep spillages clear of accommodation and service spaces and 3m beyond these, up to a height of 2.4m above the deck
(e) Areas on open deck over all cargo tanks where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3m fore and aft on open deck, up to a

height of 2.4m above the deck surrounding open or semi-enclosed spaces of (B)

(f) Spaces forward of the open deck specified in (e) and (B) (k), below the level of the main deck, and having an opening on to the main deck or at a level less than 0.5m above the main deck, unless ;

(i) the entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 5m from the foremost cargo tank and at least 10m measured horizontally from any cargo tank outlet or gas or vapour outlet ; and

(ii) the spaces are mechanically ventilated

(g) Ballast pump room adjacent to cargo tanks

(2) In tankers carrying flammable liquids having a flash point exceeding 60°C(closed cup test), the following spaces and zones are to be considered as dangerous spaces.

(A) In tankers carrying cargoes that are heated more than temperature which is 15°C lower than the flash point, the classification of hazardous areas and spaces are the same as the requirements specified in (1)

(B) In tankers carrying cargoes that are heated less than temperature which is 15°C lower than the flash point or cargoes that are not heated, the hazardous areas are classified in Zone 2 as follows

(a) Cargo tanks

(b) Slop tanks

(c) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks

(d) Interior of cargo pipes

3. System of supply

(1) The system of power supply is to be one of the following systems:
Two-wire insulated for $d.c.$
Two-wire insulated for single-phase $a.c.$,
Three-wire insulated for three-phase $a.c.$,

(2) Generator circuits, power supply and distribution circuits are not to be earthed, nor to depend on hull return system except the following:

(a) Impressed current cathodic protection system for outer hull protection only,

(b) Earth indication devices or other alternative means, however, in no case the circulation current to exceed 30 mA,

(c) Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines,

(d) Electrical circuits having no fear of causing hull current in the dangerous spaces, subjected to the approval of the Society.

4. Isolating means

Distribution circuits for the electrical equipments installed in dangerous spaces are to be provided on each circuit with multipole linked isolation switches in a safe space. In addition, the isolation switches are to be clearly labelled to identify the electrical equipment to be connected with, and further effective means are to be provided to avoid danger due to unauthorized operation of the isolation switches.

5. Earth detection

Excluding intrinsically safe circuits, the feeders and distribution circuits to be connected to the electrical equipments in the dangerous spaces or to run through the dangerous spaces are to be provided with such devices that keep monitoring the insulation levels and will give an alarm in case of abnormally low level.

1102. Wirings in dangerous spaces

1. General

Cables are generally not to be installed in the dangerous spaces specified in **1101. 2.** Where installation of cables in such spaces is unavoidable, it is to comply with the following requirements.

2. Selection of cables

Cables are to be one of the following. Where corrosion may be expected, a non-metallic impervious sheath is to be applied over metallic sheath or armour of cables for corrosion protection.

(1) Mineral insulated and metallic sheathed.
(2) Lead sheathed and armoured.
(3) Non-metallic impervious sheathed and armoured.

3. Installation of cables

(1) Cables are to be installed as close to the hull center line as practicable.
(2) Cables are to be installed sufficiently distant from decks, bulkheads, tanks and various kinds of pipes.
(3) Cables which are installed on the fore and aft gangways and the decks are to be protected against mechanical damage. Further, the cables and their supports are to be fitted in such a manner as to withstand expansion and contraction and other effects of the hull structure.
(4) The penetration part of the cables or cable pipes through decks and bulkheads of the dangerous spaces is to be constructed so as to maintain gastightness and liquid-tightness as the case may require.
(5) When mineral insulated cables are used, special precautions are to be taken to ensure sound terminations.

4. Earthing of cables

All metallic protective coverings of power and lighting cables passing through dangerous spaces, or connected to equipment in such spaces, are to be earthed at least at each end.

5. Intrinsically safe circuits

(1) The cables for intrinsically safe circuits associated with intrinsically safe type electrical equipment are to be of exclusive use, being installed separately from cables for general circuits.
(2) Intrinsically safe circuits associated with different kinds of intrinsically safe type electrical equipment are generally to be wired individually using different cables. Where it is necessary to use a multi-core cable in common, a cable which has shields by each core or each pair of cores is to be used, having such shields earthed effectively.

1103. Electrical equipment in dangerous spaces【See Guidance】

1. General

(1) Electrical equipment is generally not to be installed in the dangerous spaces specified in **1101. 2.** Where installation of electrical equipment is unavoidable, it is to comply with the following requirements.
(2) Explosion-protected electrical equipment is to comply with the requirements in **Pt 6, Ch 1, Sec 9.**
(3) Electrical measuring, monitoring, control and communication apparatus are to be of intrinsically safe type.
(4) Portable lamps are to be of intrinsically safe or flameproof type with self-contained battery or of air-driven type with pressurized enclosure.

2. All dangerous spaces specified in 1101. 2

Intrinsically safe type electrical equipment may be installed.

3. Cathodic protection

(1) Impressed current systems are not to be permitted in oil cargo tanks.
(2) Magnesium or magnesium alloy anodes are not to be permitted in oil tanks.
(3) Aluminium anodes are only permitted in cargo tanks of tankers in locations where the potential energy does not exceed 275 N-m. Aluminium anodes are not to be located under tank hatches or Butterworth openings in order to avoid any metal parts falling on the fitted anodes, unless protected by adjacent structure.
(4) There is no restriction on the position of zinc anodes.
(5) The anodes are to have steel cores and these are to be sufficiently rigid to avoid resonance in the anode support and be designed so that they retain the anode even when it is wasted.

(6) The steel inserts are to be attached to the structure by means of a continuous weld of adequate section. Alternatively they may be attached to separate supports by bolting, provided a minimum of two bolts with locknuts are used. However, approved mechanical means of clamping will be accepted.
(7) The supports at each end of an anode are not to be attached to separate items which are likely to move independently.
(8) When anode inserts or supports are welded to the structure, they are to be arranged so that the welds are clear of stress raisers.

4. Cofferdams, double bottoms and duct-keels adjoining cargo tanks

(1) The transducers of navigation instruments such as electric depth sounding devices may be installed. The transducers are to be of totally-enclosed type and to be housed in a gastight enclosure clear of the cargo tank. The cables to the transducers are to be installed in heavy gauge galvanized steel pipes with gastight joints up to the main deck.
(2) Where the anodes or electrodes and the cables of an impressed current cathodic protection system for outer hull protection are installed in such spaces, the requirements in the preceding (1) are to be applied.
(3) Lighting fittings of flameproof type or of air-driven type with pressurized enclosure may be installed in double bottoms and ductkeels equipped with machinery which is to be manned for operation and watch. The lighting fittings are to be arranged on at least two independent circuits.

5. Dangerous spaces specified in 1101. 2 (1) (B) (e)

(1) Lighting fittings of flameproof type or of air-driven type with pressurized enclosure may be installed. Lighting fittings in the spaces which are normally attended by the personnel are to be supplied by at least two independent circuits.
(2) Cables may be run through in these spaces.

6. Dangerous spaces specified in 1101. 2 (1) (B) (f) and ballast tanks adjoining cargo tanks

(1) Electrical equipment specified in **Par 3** may be installed.
(2) Lighting fittings of flameproof type or air-driven type with pressurized enclosure may be installed in the spaces equipped with machinery which is to be manned for operation and watch.
(3) Through-runs of cables are to be subjected to the approval of the Society.

7. Dangerous spaces specified in 1101. 2 (1) (B) (d)

(1) Electrical equipment specified in **Par 3** may be installed.
(2) Lighting fittings of flameproof type of air-driven type with pressurized enclosure may be installed. Lighting fittings are to be arranged on at least two independent circuits.
(3) Where cables are run through cargo pump room entrances, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

8. Dangerous spaces specified in 1101. 2 (1) (B) (m), (l)

(1) Lighting fittings of flameproof type or air-driven type with pressurized enclosure may be installed.
(2) Where cables are run through these spaces, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

9. Dangerous spaces specified in 1101. 2 (1) (B) (g), (h), (k) and (1) (C) (b), (e)

(1) Electrical equipment of flameproof type, pressurized protected type and increased safety type may be installed.
(2) Cables may be run through the spaces. However, no cable expansion bends are to be provided in the spaces specified in **1101. 2** (8) as far as practicable.

10. Enclosed and semi-enclosed spaces having a direct opening in 1101. 2

These spaces are to be taken as equivalent to the adjacent dangerous spaces having direct openings, and the electrical installations are to be in compliance with the corresponding requirements in the preceding **Pars 1** to **8.**

11. Electric motors driving equipment in cargo pump room *(2019)*

Electric motors driving pumps located in cargo pump room spaces are to be installed in the space partitioned from these spaces by a gastight bulkhead and deck. In addition, suitable stuffing boxes are to be fitted where shafts pass through gastight bulkheads and decks. However, when the elec-

tric motor is explosion-protected type suitable for the area, the electric motor can be installed in the cargo pump room.

12. Lighting in dangerous spaces

(1) To discourage personnel from entering the cargo pump room when the ventilation is not in operation, one of the following means is to be applied.

(A) Lightings in cargo pump room are to be interlocked with ventilation system such that ventilation systems are to be in operation to energize the lighting. Failure of the ventilation systems should not cause the lighting to go out. Emergency lighting, if fitted, is not to be interlocked.

(B) Audible and visible alarms located at the door to the cargo pump room are to provide a warning if the door is opened when the cargo pump room ventilation is not in operation. A notice is to be prominently displayed on or adjacent to the pump room door to the effect that the alarms indicate that the pump room ventilation is not in operation, that the pump room atmosphere may therefore be hazardous, and that the pump room is not to be entered until verified safe. The audible alarm is also to sound on the navigation bridge. Reset of the alarm is to be provided from the navigation bridge only.

13. Electric motors driving ventilators for dangerous spaces

Electric motors driving the ventilators for cargo pump rooms and the exhaust ventilators for other dangerous spaces are not to be installed in the ventilation ducts.

1104. Earthing and bonding of cargo tanks, process plant and piping systems for the control of static electricity【See Guidance】

1. Bonding straps are required for cargo tanks and process plant, piping systems which are not permanently connected to the hull of the ship as the followings.

(1) Independent cargo tanks
(2) Cargo tanks and piping systems which are electrically separated from the hull of the ship
(3) Pipe connections arranged for the removal of spool pieces
(4) Wafer-style valves with non-conductive (e.g PTFE) gaskets or seals

2. Where bonding straps are required, they are to comply with the followings.

(1) The bonding straps are to be clearly visible so that any shortcomings can be clearly detected.
(2) The bonding straps are to be designed and sited so that they are protected against mechanical damage and, as far as possible, they are not affected by high resistivity contamination(corrosive products or paint).
(3) The bonding straps are to be easy to install and replace. ⚓

CHAPTER 2 ORE CARRIERS

Section 1 General

101. Application 【See Guidance】

1. The construction and equipment of ships intended to be registered and classed as "Ore Carriers" are to be in accordance with the requirements in this Chapter or equivalent thereto.

2. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.

3. The requirements in this Chapter are framed for ships of usual form, having single deck, machinery aft, two rows of longitudinal watertight bulkheads, and also having double bottoms under ore holds, decks and bottoms with longitudinal framing.

4. Ore carriers which are different construction from the scope of application and the requirements in this Chapter are considered to be not applicable, matters are to be determined as deemed appropriate by the Society.

5. Except where specially required in this Chapter, the requirements in **Ch 3** are to be applied.

102. Direct strength calculation 【See Annex 7-10】

When the scantlings of each members are determined based upon direct calculations defined **Pt 3, Ch 1, 206.** of the Rules, concerned members, load cases, the scope of strength calculation and permissible stresses are to be at the discretion of the Society.

Section 2 Double bottoms

201. General

1. The specific gravity γ of cargoes described in this Section is as defined by the following formula :

$$\gamma = \frac{W}{V}$$

where:

W = mass of cargoes for the hold under consideration (t).

V = volume of the hold excluding its hatchway (m^3)

2. The height of double bottoms is to be determined in such a manner that the center of gravity of the ship is sufficiently high in full load condition. However, the height h is not to be less than that obtained from the following formula.

$$h = B/20$$

However, in no case is the value of h to be less than 0.76 m.

3. Floor plates or bottom transverses are to be arranged at the positions of bulkheads or transverses in side tanks or void spaces.

4. Where double bottoms are intended to be deep tanks, the scantlings of members in double bottoms are to be in accordance with the relevant requirements in **Sec 3**, in addition to those of this Section. Bottom shell plating is to be in accordance with **301.**, **302. 1.** and **5.** Inner bottom plating is to be in accordance with **301.**and **302. 1.** Bottom longitudinals are to be in accordance with **303. 1.**, **3.**, **4.**, **6.** and **8.** Inner bottom longitudinals are to be in accordance with **303. 4.**, **6.** and **8.**

Girders are to be in accordance with **301.** However, when obtaining the value of coefficient C_2 in **302. 1.**, "longitudinal bulkhead plating" is to be construed as "bottom shel plating" or "inner bottom plating".

202. Inner bottom plating

1. The thickness of inner bottom plates is not to be less than that obtained from the following formulae, whichever is the greater :

$$t_1 = CS\sqrt{hK} + 1.5 \ (\mathrm{mm})$$
$$t_2 = 0.28(M_{GR}+50)\sqrt{SK}+4.5 \ (\mathrm{mm})$$

where:

S = spacing of inner bottom longitudinals (m).

M_{GR} = mass of grab (t)

h = vertical distance from the top of the inner bottom plates to the upper deck measured at the centre line of the ship (m).

K = as specified in **Pt 3, Ch 1, 403. 2.**

C = coefficient obtained from the following formulae, depending on the value of l/S

$$\left(0.46\frac{l}{S}+2.64\right)\sqrt{\gamma} \quad : \text{for } 1 \le \frac{l}{S} < 3.5$$
$$4.25\sqrt{\gamma} \quad : \text{for } 3.5 \le \frac{l}{S}$$

l = spacing of solid floor(m)

γ = as specified in **201. 1.**

203. Longitudinals

1. The section modulus of bottom longitudinals is not to be less than the value obtained from the following formula.

$$Z = 100C_1C_2Shl^2 \quad (\mathrm{cm}^3)$$

S = spacing of bottom longitudinals (m).

l = distance between floor (m).

h = distance from the longitudinals under consideration to the following point above the top of the keel

$$h = d + 0.026L'$$

L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.

C_1 = coefficients determined according to values of L as specified below :

C_1 = 1.0 where L is 230 m and under,

1.07 where L is 400 m and above.

For intermediate values of L, C_1 are to be obtained by linear interpolation.

C_2 = coefficients is obtained from the following formula :

$$C_2 = \frac{K}{24 - 15.0 f_B K}$$

K = as specified in **202. 1.**

f_B = as specified in **Pt 3, Ch 1, 124.**

2. The section modulus of inner bottom longitudinals is not to be less than that obtained from the following formula. However, the section modulus of inner bottom longitudinals is not to be less than 0.75 times that of the bottom longitudinals as specified in **Par 1** at the same location.

$$Z = 100 C_1 C_2 S h l^2 \quad (\mathrm{cm}^3)$$

S = spacing of inner bottom longitudinals (m).

l = distance between floor (m).

h = as specified in **202. 1.**

C_1 = value of γ specified in **201. 1.**

However, values of C_1 are not to be less than 0.9.

C_2 = coefficients is obtained from the following formula :

$$C_2 = \frac{K}{24 - 11.4 f_B K}$$

K = as specified in **202. 1.**

f_B = as specified in **203. 1.**

3. Buckling strength of longitudinal is to be in accordance with the requirements (1) and (2) below. In case where the Society specially considers necessary according to the materials, scantling, geometries and the point of arrangement of these structural members, detailed assessment may be required.

(1) As for flat bars used for longitudinals, the ratio of depth to thickness is not to exceed 15.

(2) The full width of face plate of longitudinals is not to be less than that obtained from the following formula:

$$b = 69.6 \sqrt{d_0 l} \quad (\mathrm{mm})$$

where :

d_0 = depth of web of longitudinal (m)

l = spacing of girders (m)

204. Girders

The arrangements and the scantling of girders in double bottoms are to be determined by direct calculations.

Section 3 Wing Tanks or Void Spaces

301. Minimum thickness

1. The thickness of structural members in deep tanks such as bulkhead plating, floors, girders including struts and their end brackets is not to be less than the value determined from **Table 7.2.1** according to the Length of Ship.
2. The thickness of structural members in deep tanks is not to be less than 7 mm.

Table 7.2.1 Minimum thickness

L (m)													
	and over		105	120	135	150	165	180	195	225	275	325	375
	and under	105	120	135	150	165	180	195	225	275	325	375	
Thickness (mm)		8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5

302. Bulkhead plating

1. The thickness of bulkhead plating in deep tanks is not to be less than that obtained from the following formula. However, the thicknessof plating with only one side in contact with sea water may be 0.5 mm less than the greatest of the values obtained from the following formula:

$$t_1 = C_1 C_2 S\sqrt{h} + 2.5 \quad (\text{mm})$$

S = spacing of stiffeners (m).

h = water head of h_1, h_2 or h_3 is obtained from **Table 7.2.2**, whichever is the greater. When the ship use the flow-through ballast water exchange operations method, h_4 and h_5 are to be additionally considered. ***(2020)***

C_1 = as specified in **203. 1.**

C_2 = determined from **Table 7.2.3**

In determining the thickness of longitudinal bulkhead plating, coefficient C_2 for h_1 may be gradually reduced for the parts forward and aftward the midship part, and it may be taken as $3.6\sqrt{K}$ in calculations at $0.1L$ from fore end and aft end.

Table 7.2.2 Water head h *(2020)*

h_1	Vertical distance from the lower edge of the bulkhead plating under consideration to the mid-point between the point on tank top and the upper end of the overflow pipe. For side shell plating, a water head corresponding to the minimum draught amidship $d_{\min}$ (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be $d_{\min}$, value at point $d_{\min}$ above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation
h_2	As obtained from the following formula $h_2 = 0.85(h_1 + \Delta h)$ where: Δh = additional water head given by the following formula; For L-type, U-type etc. of tanks, Δh is to be determined as deemed appropriate by the Society $\Delta h = \frac{16}{L}(l_t - 10) + 0.25(b_t - 10)$ l_t = tank length (m), 10, when less than 10 m. b_t = tank breadth (m), 10, when less than 10 m
h_3	Value (m) obtained by multiplying 0.7 by vertical distance from the lower edge of the bulkhead plating under consideration to the point 2.0 m above the top of overflow pipe.
h_4	Vertical distance from the lower edge of the bulkhead plating under consideration to the top of the overflow pipe (or air pipe) to the point where the overpressure is added (m). (Overpressure : due to sustained liquid flow through overflow pipe in case of overfilling or filling during flow through ballast water exchange. It is to be defined by the designer, but not to be less than 2.5.)
h_5	$0.85\,(h_4 + \Delta h)$ Δh : as specified in h_2

Table 7.2.3 Coefficient C_2

For h_1	longitudinal bulkhead of longitudinal framing	longitudinal bulkhead of transverse framing
	$C_2 = 13.4\sqrt{\frac{K}{27.7-\alpha K}}$	$C_2 = 100\sqrt{\frac{K}{767-\alpha^2 K^2}}$
	minimum : $3.6\sqrt{K}$	
For h_2 or h_3 and for transverse bulkhead	$C_2 = 3.6\sqrt{K}$	

α = either α_1 or α_2 according to value of y. However, value of α is not to be less than α_3.

$$\alpha_1 = 15.0\, f_D\left(\frac{y-y_B}{Y'}\right) \quad \text{for} \quad y > y_B$$

$$\alpha_2 = 15.0\, f_B\left(\frac{y_B-y}{y_B}\right) \quad \text{for} \quad y \le y_B$$

$$\alpha_3 = \beta\left(\frac{B-2b}{B}\right)$$

f_D and f_B = as specified in **Pt 3, Ch 1, 124.**

y = distance from the top of keel to the lower edge of plating when the platings under consideration are under y_B, to the upper edge of plating when the platings under consideration are above y_B and to the longitudinals stiffener under consideration for longitudinal stiffener, respectively (m).

y_B = distance from the top of keel to the horizontal neutral axis of transverse section amidship (m).

Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5), (a) or (b).

β = coefficient determined according to the values of L as specified below: For intermediate values of L, the value of b is to be determined by linear interpolation:

$\beta = 6/a$ when L is 230 m and under

$\beta = 10.5/a$ when L is 400 m and above

a = $\sqrt{K}$ when high tensile steels are used for not less than 80 % of side shell platings at the transverse section amidship and 1.0 for other parts.

b = horizontal distance from the side shell plating to the longitudinal bulkhead plating under consideration (m).

2. The thickness of longitudinal bulkhead plating is to be in accordance with the requirements in **Pt 3, Ch 14.** The thickness of longitudinal bulkhead plating forming deep tanks is also to be in accordance with the requirements in **Par 1** above.

$$t = CS\sqrt{hK} + 1.5 \quad (\text{mm})$$

where:

S = length of the shorter side of the panel enclosed by stiffeners, etc. (m)

h = vertical distance from the lower end of the hopper plate to the upper deck at centre line (m).

C = coefficient obtained from the following formula. However, in no case is it to be less than 3.2.

$$C = 4.25\, C_1\, C_2 \sqrt{\gamma}$$

C_1 = coefficient obtained from the following formula

where $1 \leq \frac{l}{S} < 3.5$ C_1 = $\left(0.11\frac{l}{S} + 0.615\right)$

where $3.5 \leq \frac{l}{S}$ C_1 = 1

l = length of the longer side of the panel enclosed by stiffeners, etc. (m)

C_2 = coefficient obtained from the formula in **Table 7.2.4.**

γ = as specified in **201. 1.**

β = as specified in **Fig 7.2.1**

Table 7.2.4 Coefficient C_2

Angle β (degree)	C_2
$\beta \leq 40^\circ$	1.0
$40^\circ < \beta < 80^\circ$	1.4 − 0.01 β
$\beta \geq 80^\circ$	0.6

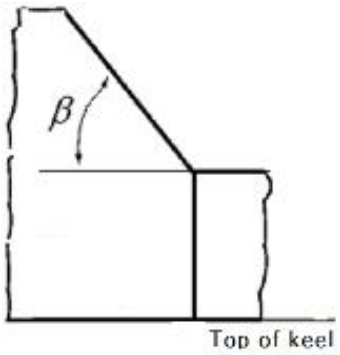


Fig 7.2.1 Measurement of β

3. In ships whose cargoes are regularly handled by grabs or similar mechanical appliances, the thickness of longitudinal bulkhead plating up to a height of 3.0 m above the lowest point of the inner bottom is not to be less than those obtained from the following formula in addition to the requirements in **Par 2.**

$$t = 0.28(M_{GR} + 42)\sqrt{SK} + 5.0 \quad (\text{mm})$$

where:

S = spacing of stiffeners (m).

M_{GR} = mass of grab (t)

4. The thickness of longitudinal bulkhead plating is to be in accordance with the requirements in **Pt 3, Ch 3, 302.** and **Pt 3, Ch 3, 303.** as well as **Pt 3, Ch 3, Sec 4.**

5. The thickness of shell and deck plating forming deep tanks, which are taken as bulkhead plating in deep tanks, is to be in accordance with the requirements in **Pt 3, Ch 4** and **Pt 3, Ch 5** respectively, and is not to be less than the value obtained from the requirements in **Par 1** above, which may be reduced by 0.5 mm.

6. The thickness of tank top in deep tanks is not to be less than the value obtained from the requirements in **Par 1** above plus 1.0 mm.

303. Longitudinals and Stiffeners

1. The section modulus of bottom longitudinals is not to be less than the value obtained from the formula in **203. 1.**

2. The section modulus of side longitudinals including bilge longitudinals is not to be less than the value obtained from the following formula:

$$Z = 100 C_1 C_2 S h l^2 \quad (\mathrm{cm}^3)$$

S = spacing of side longitudinals (m).
l = spacing of girders (m).
h = distance from the longitudinals under consideration to the following point above the top of the keel
$h = d + 0.038L'$
L' = specified in **203. 1.**
C_1 = specified in **203. 1.**
C_2 = coefficients is obtained from the following formula :

$$C_2 = \frac{K}{24 - \alpha K}$$

α = α_1 or α_2 as given below, whichever is greater

$$\alpha_1 = 15.5 f_D \left(\frac{y - y_B}{Y'} \right) \quad \text{for} \quad y > y_B$$
$$= 15.5 f_B \left(\frac{y_B - y}{y_B} \right) \quad \text{for} \quad y \leq y_B$$

f_B = specified in **203. 1.**
y = Vertical distance from the top of the keel to the longitudinals under consideration (m).
y_B = distance from the top of keel to the horizontal neutral axis of transverse section at amidship (m).
α_2 = coefficient determined according to the values of L as specified below: For intermediate values of L, the value of α_2 is to be determined by linear interpolation:
α_2 = 6/a when L is 230 m and under,
10.5/a when L is 400 m and above.
a = $\sqrt{K}$ when high tensile steels are used for not less than 80 % of side shell platings at the transverse section amidship and 1.0 for other parts.

However, the section modulus does not need to exceed that of bottom longitudinals specified in **Par 1** above, but is not to be less than the value obtained from the following formula:

$$Z = 2.9K\sqrt{L}Sl^2 \quad (\mathrm{cm}^3)$$

3. For side longitudinals, bottom longitudinals and longitudinals stiffeners attached to longitudinals bulkheads in deep tanks, sufficient consideration is to be taken against fatigue strength.

4. For the parts forward and aftward of midship part, the scantlings of bottom longitudinals and side longitudinals may be gradually reduced and at the end parts they may be reduced by 15 % of the values obtained from the requirements in **Pars 1** and **2** above respectively. However, the scantlings of bottom longitudinals and side longitudinals are not to be less than those required in **Pars 1** and **2** above respectively under any circumstances for the parts between a point $0.15L$ from the fore end and the collision bulkhead.

5. The section modulus of stiffeners attached to longitudinal bulkheads is to be in accordance with the requirements in **Pt 3, Ch 14**, and is to be as specified in the following (1) and (2).

(1) The section modulus of longitudinal stiffeners is not to be less than the value obtained from the following formula:

$$Z = C_1C_2Shl^2 \quad (\mathrm{cm}^3)$$

S = spacing of longitudinal stiffeners (m).

h = Vertical distance from the stiffener under consideration to the upper deck at the centerline

l = length of longitudinal stiffener between transverse webs (m).

C_1 = coefficient given in **Table 7.2.5.** according to the values of β specified in **302. 2.** and γ specified in **201. 1.**

C_2 = coefficients is obtained from the following formula :

$$C_2 = \frac{K}{24 - \alpha K}$$

α = α_1 or α_2 as given below, whichever is greater

$$\alpha_1 = 15.5\, f_D\left(\frac{y - y_B}{Y'}\right) \quad \text{for} \quad y > y_B$$

$$= 15.5\, f_B\left(\frac{y_B - y}{y_B}\right) \quad \text{for} \quad y \le y_B$$

f_B = specified in **203. 1.**

y = specified in **303. 2.**

y_B, Y' and f_D = specified in **302. 1.**

Table 7.2.5 Coefficient C_1

Angle β (degree)	C_1
$\beta \le 40^\circ$	$130\,\gamma$
$40^\circ < \beta < 80^\circ$	$(214 - 2.1\,\beta)\gamma$
$\beta \ge 80^\circ$	$46\,\gamma$

(2) The section modulus of transverse stiffeners is not to be less than that obtained from the following formula :

$$Z = CKShl^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of transverse stiffeners (m).

h = vertical distance from the mid-point of l to the upper deck at centre line (m).

l = distance between the supports of stiffeners (m).

C = coefficient obtained from the formula given in **Table 7.2.6** according to the values of β specified in **302. 2.** and γ specified in **201. 1.**

Table 7.2.6 Coefficient C

Angle β (degree)	C
$\beta \leq 40^\circ$	7.8γ
$40^\circ < \beta < 80^\circ$	$(12.8 - 0.125b)\gamma$
$\beta \geq 80^\circ$	2.8γ

6. The section modulus of stiffeners attached to bulkhead plating in deep tanks is not to be less than the value obtained from the following formula:

$$Z = 125 C_1 C_2 C_3 S h l^2 \quad (\mathrm{cm}^3)$$

Where:

S = spacing of stiffeners (m).

h = water head h_1, h_2 or h_3 as specified in **Table 7.2.2.** Where, however, "from the lower edge of the bulkhead plating under consideration" is to be construed as "from the stiffener under consideration" for horizontal stiffeners, and as "from the mid-point of l" for vertical stiffeners. When the ship use the flow-through ballast water exchange operations method, h_4 and h_5 as specified in **302.** are to be additionally considered. ***(2020)***

l = distance between the supports of stiffeners (m).

C_1 = specified in **203. 1.**

C_2 = value obtained from following formula. The value C_2 for h_1, however, is to be as obtained from the formula in **Table 7.2.7.**

$$C_2 = \frac{K}{18}$$

For the parts forward and aftward of midship part in determining the section modulus of stiffeners attached to bulkhead plating, coefficient C_2 for h_1 may be gradually reduced, and at the end parts C_2 may be as $K/18$.

C_3 = as determined from **Table 7.2.8** according to the fixity condition of stiffener ends;

Table 7.2.7 Coefficient C_2

Bulkhead and framing systems	C_2
Longitudinal bulkhead of longitudinal framing system	$C_2 = \frac{K}{24-\alpha K}$, minimum $C_2 = \frac{K}{18}$
Longitudinal bulkhead of transverse framing system, transverse bulkhead	$C_2 = \frac{K}{18}$

α = as specified in **302. 1.**
However, "the lower edge of the bulkhead plating under consideration" and "the bulkhead plating under consideration" are to be construed as "the stiffener under consideration" in applying the requirements for y and b.

Table 7.2.8 Coefficient C_3

One end of stiffener / The other end of stiffener	Connection be hard bracket	Connection be soft bracket	Supported by rule girder or lug connection	Snip
Connection be hard bracket	0.70	1.15	0.85	1.30
Connection be soft bracket	1.15	0.85	1.30	1.15
Supported by rule girder or lug connection	0.85	1.30	1.00	1.50
Snip	1.30	1.15	1.50	1.50

1. Connection by hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent members mentioned above. (See **Pt 3, Fig 3.14.2** (a))
2. Connection by soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (See **Pt 3,** Fig 3.14.2 (b))

7. Buckling strength of longitudinal frames, beams and stiffeners is to be in accordance with the requirements (1) to (3) below. In case where the Society specially considers necessary according to the materials, scantling, geometries and the point of arrangement of these structural members, detailed assessment may be required.

(1) Longitudinals beams, side longitudinals attached to sheer strakes and longitudinal stiffeners attached to the longitudinal bulkhead within $0.1D$ from the strength deck are to have a slenderness ratio not exceeding 60 at the midship part as far as practicable.

(2) As for flat bars used for longitudinal beams, frames and stiffeners, the ratio of depth to thickness is not to exceed 15.

(3) The full width of face plate of longitudinal beams, frames and stiffeners is not to be less than that obtained from the following formula:

$$b = 2.2\sqrt{d_0 l} \quad (\mathrm{mm})$$

where :

d_0 = depth of web of longitudinal beam, frame or stiffener (mm).

l = spacing of girders (m).

8. In case where assembled members, special shape steels or flanged plates are used for frames, beams or stiffeners in cargo oil tanks and deep tanks whose scantlings are specified only in terms of section modulus, the thickness of web is not to be less than the value from the following formula. However where the stiffener have the sufficient buckling strength or the depth of web is intended to be greater than the required level due to reasons other than strength, it may be suitably modified. *(2019)*

$$t = 0.015 k_0 d_0 + 2.5 \quad (\mathrm{mm})$$

where:

d_0 = depth of web (mm).

k_0 = coefficient according to the location of stiffeners as given **Table 7.2.9.**

Table 7.2.9 Coefficient k_0

Locations	k_0
Bottom longitudinals located not more than $0.25D$ above top of keel	$k_0 = \sqrt{0.25\left(3f_B + \frac{1}{K}\right)}$
Deck longitudinals located not less than $0.25D$ below deck	$k_0 = \sqrt{0.25\left(3f_D + \frac{1}{K}\right)}$
Other structural members	$k_0 = \sqrt{0.25\left(3 + \frac{1}{K}\right)}$
f_D and f_B = specified in **302. 1.**	

9. The section modulus of longitudinal beams is not to be less than the value obtained from the requirements in **Pt 3, Ch 10, 303.** The section modulus of bottoms longitudinals, side longitudinals and longitudinal beams in deep tanks is not to be less than the value obtained from the requirements in **Par 6** above.

304. Girders【See Guidance】

1. The arrangements and scantlings of girders in wing tanks or void spaces are to be determined based upon direct strength calculations.

2. Notwithstanding the requirement in **Par 1,** the scantlings of girders in wing tanks or void spaces may be determined in accordance with the requirements in the following **Par 3** to **Par 10** for ships with L less than 230 m.

3. The construction and scantlings of transverses, girders, webs and cross ties are to be in accordance with the requirements in the following (1) to (5). The construction and scantlings of transverses, girders, webs and cross ties in deep tanks are also to be in accordance with the requirements in **Pt 3, Ch 15.**

(1) The thickness of transverses, girders, webs and cross ties are not to be less than the value given in **Table 7.2.1** according to the length of the ship.

(2) Girders and transverses in the same plane are to be so arranged that abrupt changes in strength and rigidity are avoided; they are to have brackets of sufficient scantlings and with properly rounded corners at their ends.

(3) The depth of girders and transverses is not to be less than 2.5 times that of slots for frames, beams and stiffeners.

(4) The thickness of face plates forming a girder is to be greater than the thickness of web, and the total width is not to be less than that obtained from the following formula :

$$b = 2.7\sqrt{d_0 l'}$$

where:

d_0 = depth of girder (mm)

l' = distance between supporting points of girders (m). Where, however, if effective tripping brackets are provided, they may be regarded as supporting points.

(5) Transverses are to be effectively stiffened according to the following (a) to (c):

(a) The depth of flat bar stiffeners provided on transverses is not to be less than 0.08 d_0. However, where the stiffeners range throughout the full depth of the transverse, d_0 is to be taken as the depth of transverse, and where the stiffeners are fitted in parallel with face plates, d_0 is to be taken as the spacing of the tripping brackets. The depth and thickness of the flat bar stiffeners which support longitudinals penetrating transverses are to be as required in **Pt 3, Ch 7, 206. 2.**

(b) Tripping brackets are to be provided on the web plate of transverses at the inner edge of end brackets and at the intersectional part of crossties, etc. and also at the proper intervals in order to support transverses effectively. Where the breadth of face plates exceeds 180 mm on either side of the web plate, these brackets are to be so arranged as to support the face plate as well.

(c) Lower brackets of side transverses and transverses on longitudinal bulkheads and web plates in the vicinity of the edge of the brackets are to be provided with closely-spaces stiffeners.

4. The scantlings of side transverses are to be in accordance with the requirements in the following (1) to (5):

(1) Symbols used in this Paragraph are defined as follows:

$$Q = \alpha S h l_0$$

α = 1.0 where L is 230 m and under,
1.2 where L exceeds 400 m
For intermediate values of L, α is to be obtained by linear interpolation.

h = distance from the mid-point of l_0 to the point H_2 above the top of keel (m).

h_s = distance from the mid-point of b_s to the point H_2 above the top of keel (m).

$$H_2 = d + 0.038L' \quad (\mathrm{m})$$

L' = length of ship (m). Where L' exceeds 230 m, L' is to be taken as 230 m.

l_0 = overall length of side transverses (m), which is equal to the distance between the inner surfaces of face plates of bottom transverses and deck transverses. (See **Fig 7.2.2**)

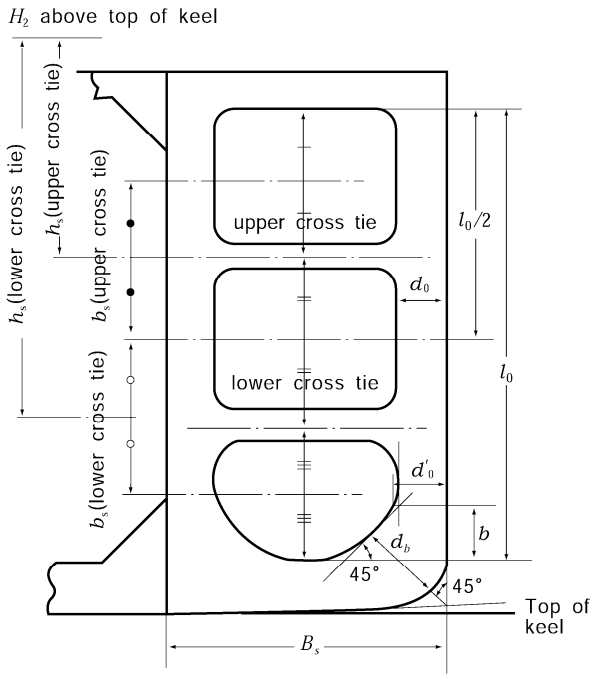


Fig 7.2.2 Measurement of l_0, d_0, b and b_s

S = spacing of transverses (m).

S' = spacing of stiffeners provided depthwise on the web plates of transverses at the portion where cross ties are connected (m).

k = Correction factor for brackets as given by the following formula:

$$k = 1 - \frac{0.65(b_1 + b_2)}{l}$$

b_1, b_2 = arm length of brackets at both ends of girders and transverses respectively (m).

l = overall length of girders and transverses (m), which is equal to l_0.

b = length of arm of the lowest bracket (m). (See **Fig 7.2.2**)

b_s = width of the area supported by cross ties (m). (See **Fig 7.2.2**)

d_0' = depth of side transverses at the inner edge of the lowest bracket (mm). (See **Fig 7.2.2**)

a = depth of slot in the vicinity of inner edge of the lowest bracket. Where, however, the slots are provided with collar plates, a may be taken as zero.

A = section area effective to support the axial force from cross tie (cm^2), which is to be taken as following (a) to (c):

(a) Where the face plates of cross ties are continuous to the face plates of transverses in an arc form or a similar form, A is the total sum of the sectional area of the web plate of transverse at the portion between the contact points of the tangents to the arc or the similar curve making an angle of 45° to the direction of cross tie, that of the stiffener provided in the axial direction of cross tie on the web plate between the contact points, and 0.50 times that of the face plates at the contact points. (See Fig **7.2.3** (a))

(b) Where the face plates of cross ties are continuous to the face plates of transverses in the form of straight line with rounded corners, A is the total sum of the sectional area of the web plate of transverse at the portion between the midpoints of the intersections of the extensions of the lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the inner surface of face plates at the transforming parts, that of the stiffener provided in the axial direction of cross tie on the web plate between the above mentioned mid-points and 0.50 times that of the face plates at the mid-points. (See Fig **7.2.3** (b))

(c) Where the face plates of cross ties are joined directly to the face plates of transverses with a right or nearly right angle and both face plates are connected with brackets and further, stiffeners are provided on the web plate of transverses on the extended lines of face plates of cross tie, A is the total sum of the sectional area of the web plate of transverse at the portion between the mid-points of the intersections of the extensions of lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the free edge lines of brackets, and that of the stiffeners provided as mentioned above. (See Fig **7.2.3** (c))

C_0, C_1, C_2 = coefficients given in **Table 7.2.10** according to the number of cross ties respectively.

Table 7.2.10 Coefficients C_0, C_1, C_2 and C_2'

Number of cross ties	C_0	C_1	C_2	C_2'
0	0.150	55.7	5.07	7.14
1	0.110	44.8	2.70	4.42
2	0.100	39.4	2.28	3.74
3	0.095	36.2	2.12	3.49

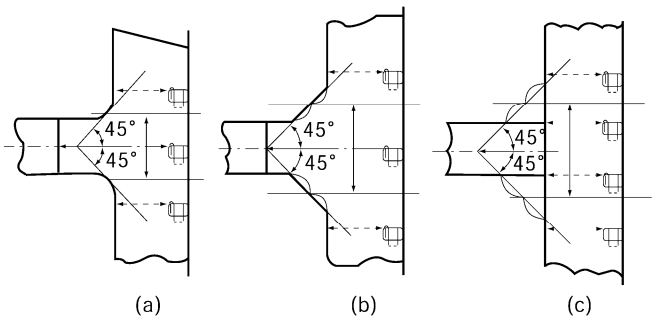


Fig 7.2.3 Extent for total sectional area

(2) The depth of transverses is not to be less than $C_0 l_0$ (m) at the mid-point of l_0. Where the transverses are of tapered form, the reduction in depth at the upper end is not to exceed 10 % of the depth at the mid-point of l_0, and the rate of increase in depth at the lower end is not to be less than that of reduction at the upper end.

(3) The web thickness of transverses at the inner edge of brackets at the lower ends is not to be less than that obtained from the following formula. Where, however, bottom transverses and longitudinal bulkheads in centre tanks or inner tanks are connected with large brackets extending to the lowest cross ties, the web thickness of side transverses may be properly reduced.

$$t = \left(C_1 - 148 \frac{b}{l_0} \right) \frac{KQ}{d_0' - a} + 2.5 \quad (\mathrm{mm})$$

(4) The web thickness of transverses at the portion where cross ties are connected is not to be less than that obtained from the following formula. Where slots are provided in the web at the portion where cross ties are connected, the slots are to be effectively covered with collar plates.

$$t = 16 \sqrt{\frac{\alpha S b_s h_s}{A}} \times S' \quad (\mathrm{mm})$$

(5) The section modulus of transverses at the span is not to be less than that obtained from the following formula :

$$Z = C_2 K k^2 Q l_0 \quad (\mathrm{cm}^3)$$

5. The scantlings of transverses on longitudinal bulkheads are not to be less than the values obtained from the requirements in **Par 4** (2) to (5) above correspondingly. For transverses without cross ties, h is to be the distance from the mid-point of l_0 to the top of the cargo hatch.

6. The scantlings of bottom transverses are to be in accordance with the requirements in the following (1) to (3):

(1) The rigidity of bottom transverses is to be well balanced with that of side transverses.

(2) The section modulus of bottom transverses at the span is not to be less than that obtained from the following formula:

$$Z = 9.3 K \alpha k^2 S h_1 l_1^2 \quad (\mathrm{cm}^3)$$

where :

α, k, S = as specified in **Par 4** (1).

h_1 = As given by the following formula:

$d + 0.026L'$ (m)

L' = as specified in **Par 4** (1).

l_1 = overall length of bottom transverses (m), which is equal to the distance between the inner surface of face plates of bottom transverses and that of vertical webs on longitudinal bulkheads.

(3) The section modulus of transverses at bilge and at the lower end of longitudinal bulkheads is not to be less than that obtained from the following formula. In calculating the section modulus, the neutral axis of section is to be taken as located at the middle of the depth d_b (See Fig **7.2.2**) of transverses.(*2019*)

$$Z = C_2' K Q l_0 \quad (\mathrm{cm}^3)$$

where:

Q, l_0 = as specified in **Par 4** (1) respectively.

C_2' = coefficient given in **Table 7.2.10** according to the number of cross ties.

7. The scantlings of deck transverses are to be in accordance with the requirements in the following (1) to (2):

(1) The rigidity of deck transverses is to be well balanced with that of side transverses.

(2) The section modulus of deck transverses is not to be less than that obtained from the following formula:

$$Z = 3Kk^2 S\sqrt{L}\, l_2^{\,2} \quad (\mathrm{cm}^3)$$

where:

k, S = as specified in **Par 4** (1) respectively.

l_2 = overall length of deck transverses (m), which is equal to the distance between the inner edges of face plates of side transverses and that of vertical webs on longitudinal bulkheads.

8. The web thickness t of transverses is not to be less than the value obtained from the following formula:

$$t = \frac{C d_0}{\sqrt{K}} + 2.5 \quad (\mathrm{mm})$$

where:

d_0 = depth of web plates (m). Where stiffeners are provided horizontally on the midpart of web plates, distance between the stiffener and shell plating or face plate (m), or between the stiffeners (m).

C = coefficient determined from **Table 7.2.11,** according to the ratio of S to d_0 and the stiffened panel arrangement, where S is the spacing of stiffeners provided on web plates in the depthwise (m). For the intermediate value of S/d_0, C is to be obtained by linear interpolation. The girders situated higher than $D/3$ above the top of keel or the lower edge of face plate at the lower side of the second cross ties from deck, whichever is the lower, may have the web thickness as obtained from the formula with its first term multiplied by 0.85, subject to the requirements of (i) and (ii) in this Sub-paragraph (b).

(a) Where no stiffener is provided in parallel with face plates: C_1
Where, however, slots are provided, C_2 is to be used and the web thickness is not to be less than that obtained by applying the requirements of (i) in this sub-paragraph.

Table 7.2.11 Coefficients C_1, C_2 and C_3

S/d_0	C_1	C_2	C_3
0.2 or less	2.6	2.1	3.7
0.4	4.5	3.7	6.7
0.6	5.6	4.9	8.6
0.8	6.4	5.8	9.6
1.0	7.1	6.6	9.9
1.5	7.8	7.4	10.3
2.0	8.2	7.8	10.4
2.5 or more	8.4	8.0	10.4

(b) Where stiffeners are provided in parallel with face plates, for panel between face plate and stiffener or between stiffeners: C_3
However, the thickness need not exceed the value obtained by using coefficient C_1, Subject to no stiffener in parallel to face plate and no slot being provided. For panel between stiffener and shell plating: C_2

(i) Where slots are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$\sqrt{4.0\frac{d_1}{S}-1.0}$$

where :

d_1 = depth of slots (m).

where d_1/S is 0.5 or less, the multiplier is to be taken as 1.0.

(ii) Where openings are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$1+0.5\frac{\phi}{a}$$

where:

a = length at the longer side of the panel surrounded by the web stiffeners (m).

ϕ = diameter of openings (m). Where openings are of oblong, ϕ is to be the length of the longer diameter (m).

9. Where side transverses and transverses on longitudinal bulkheads in wing tanks are connected with cross ties, the construction of cross ties are to be as required in the following (1) and (2):

(1) Brackets are to be provided at the ends of cross ties to connect to transverses or girders.

(2) Where the breadth of face plates forming cross ties exceeds 150 mm on one side of the web, stiffeners connected to web and face plates are to be fitted at proper intervals.

10. Where side transverses and transverses on longitudinal bulkheads in wing tanks are connected with cross ties, the sectional area of cross ties is not to be less than the value obtained from the following formula:

$$A = CKS\, b_s h_s \qquad (cm^2)$$

S = spacing of transverses (m).

b_s = width of the area supported by cross ties (m). (See **Fig 7.2.2**).

h_s = distance from the mid-point of b_s to the point H_2 specified in **Par 4** (1) above the top of keel (m).

C = coefficient given by the following formula:

when $\frac{l}{k} > 0.6$: $C = \frac{0.77}{1-0.5\frac{l}{k\sqrt{K}}}$

when $\frac{l}{k} < 0.6$: $C = 1.1$

l = Length (m) of cross ties measured between the inner edges of the side transverses and the vertical webs on longitudinal bulkheads

k = As given by the following formula:

$k = \sqrt{I/A}$

I : The least moment of inertia of cross ties (cm^4).

A : Sectional area of cross ties (cm^2).

Section 4 Transverse Bulkheads and Stools in Ore Holds

401. Transverse Bulkheads in Ore Holds

1. The scantlings of structural members of transverse bulkheads are to be in accordance with the requirements in **Pt 3, Ch 15, Sec 2.** Where, however, in application of these requirements, h in the formulae is to be substituted by $0.36\gamma h'$, where γ is as specified in **201. 1.** Where, however, γ is less than 1.5, γ is to be taken as 1.5, and h' is to be in accordance with the following :

(1) In case of bulkhead platings, vertical distance from the lower edge of bulkhead plate to the upper deck at centre line of ship (m).

(2) Vertical distance from the mid-point of l for vertical stiffeners on bulkhead or from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners to the upper deck at centre line of ship (m). l is as specified in **Pt 3, Ch 15, 203.**

(3) Vertical distance from the mid-point of l for vertical webs supporting stiffeners or from the midpoint of S for horizontal girders to the upper deck at centre line of ship (m). l and S are as specified in **Pt 3, Ch 15, 204.**

2. Notwithstanding the requirements in **Par 1**, the scantlings of structural members of transverse bulkheads are not to be less than those specified in **Pt 3, Ch 14.** In addition, the thickness of the transverse bulkhead plating is not to be less than 7.0 mm.

3. For transverse bulkhead without lower stool, the thickness of the lowest strake of bulkhead plating is to be appropriately increased referring to the thickness of inner bottom plating.

402. Lower and Upper Stools at Transverse Bulkheads in Ore Holds

1. The thickness of hopper plate of the lower stool of transverse bulkhead is not to be less than that obtained from the formula in **302. 2.** using the value of coefficient C reduced by 10 %. However, in ships whose cargoes are handled by grabs or similar mechanical appliances, the thickness of the lower stool plating up to a height of 3.0 m above the lowest point of the inner bottom is not to be less than those obtained from the following formula in addition to the requirements in the above sentence.

$$t = 0.28(M_{GR}+42)\sqrt{SK}+6.0 \quad (\text{mm})$$

where:

S = spacing of stiffeners (m).
M_{GR} = mass of grab (t)

2. The section modulus of horizontal stiffeners provided on the side plating of the lower stool is not to be less than the value obtained from the formula in **303. 5.** (1), where the coefficient, C_2, is to be reduced by 10%. Where vertical stiffeners are provided, the section modulus is not to be less than the value obtained from the formula in **303. 5.** (2).

3. Partial girders, etc. are partially to be arranged beneath the girders in the lower stool of the transverse bulkhead.

4. The scantlings of structural members of the upper and lower stools of the transverse bulkhead are not to be less than the values obtained from the requirements in **Pt 3, Ch 14.**

Section 5 Relative Deformation of Wing Tanks

501. Relative deformation of wing tanks【See Guidance】

Where the value obtained from the following formula exceeds 0.18, special consideration is to be given to the structure of the wing tanks, except where the scantlings of members are determined by direct calculations.

$$\delta = \frac{2h - 0.65d}{n_b K_b + n_s \eta_s K_s + n_t \eta_t K_t} \cdot \frac{a}{b} l$$

where:

h = vertical distance between the top of inner bottom plating and the upper deck at the centre line of the ship (m).
l = length of one ore hold (m)
a = half-breadth of cargo hold (m)
b = Breadth of wing tank (m)
n_b, n_s and n_t = Numbers of transverse bulkheads, swash bulkheads and transverse rings in wing tanks located within l, respectively
The bulkheads at the fore and after ends of l are to be counted as 1/2, respectively.
η_s and η_t = values given in **Table 7.2.12** in accordance with the opening ratio of swash bulkheads or transverse rings For intermediate values of the opening ratio, η_s and η_t are to be obtained by interpolation
K_b, K_s and K_t = values obtained from the following formula :

$$81.0 \frac{Dt}{\alpha b} \quad (\mathrm{t/cm})$$

where:

t = mean thickness of transverse bulkhead plating in wing tanks (mm), in obtaining K_b value.
mean thickness of wash bulkhead plating in wing tanks (mm), in obtaining K_s value.
mean thickness of transverse rings in wing tanks (mm), in obtaining K_t value.
α = value obtained from the following formulae, in case where transverse bulkheads or swash bulkheads in wing tanks are of corrugated form, in accordance with the case where the corrugation is vertical or horizontal:

For vertical corrugation :

$$\frac{Girth \quad \leq ngth \quad of \quad ship \quad in \quad athwartships \quad (\mathrm{m})}{b}$$

For horizontal corrugation :

$$\frac{Girth \quad \leq ngth \quad of \quad ship \quad in \quad depthwise \quad (\mathrm{m})}{D}$$

For the case other than above, the value is to be 1.0.

Table 7.2.12 Coefficients η_s and η_t

Opening ratio (%)	η_s and η_t
0	1.00
5	0.95
10	0.80
20	0.55
30	0.35
40	0.23
50	0.15
60	0.10
70	0.06

Section 6 Decks and Miscellaneous

601. Decks, etc.

For deck plating inside the line of openings, special consideration is to be taken against buckling.

602. Drainage of Ore Holds

1. In general, one bilge suction opening is to be provided on each side of the ship at the after end of the each hold. Where the length of ore hold in ships having only one hold exceeds 66 m, additional bilge suction opening is to be arranged in a suitable position in the forward half-length of the hold.
2. Bilge wells are to be provided at suitable positions so as to protect the cover plates from the direct strike of ore and to be provided with rose boxes or other suitable means so that the suction openings may not be choked by ore dust, etc.
3. Where bilge pipes are led through double bottoms, side tanks or void spaces, non-return valves, or stop valves capable of being closed from a readily accessible position, are to be provided at their open ends.
4. Bilge suction branch pipes may be of inside diameter obtained from the formula in **Pt 5, Ch 6, 404. 2,** taking B as the mean breadth of the ore hold.

Section 7 Ore/Oil Carriers

701. General【See Guidance】

1. Such ore carriers as intended to carry oils in the ore holds and/or wing tanks (hereinafter referred to as "Ore/Oil Carriers") are to comply with the relevant requirements in **Ch 1,** in addition to those in this Section.
2. In addition to the requirements in this Section, special requirements may be given as deemed necessary for ore/oil carriers by the Society.

702. Slop Tanks

1. Cofferdams are to be provided between slop tanks and machinery spaces in accordance with the requirements of **Ch 1, 103.** In addition, cofferdams are to be provided between slop tanks and ore holds, except where the slop tanks are cleaned and gas freed at any time prior to loading ore cargoes.
2. The cofferdams specified in **Par 1** are to be capable of being flooded, except where the cofferdams are used concurrently as pump rooms, fuel oil tanks or water ballast tanks, or cargo oil tanks (in case of cofferdams between slop tanks and ore holds only).
3. Adequate ventilation is to be provided for the spaces surrounding the slop tanks.
4. Notice boards are to be erected at suitable points detailing the precautions to be observed prior to loading or unloading, or whilst carrying ore cargo with oily water in the slop tanks.
5. It is recommended to provide an inert gas system for the slop tanks. ⚓

CHAPTER 3 BULK CARRIERS

Section 1 General

101. Application 【See Guidance】

1. The construction and equipment of ships intended to be registered as "Bulk Carriers" are to be in accordance with the requirements in this Chapter or equivalent thereto.
2. The requirements in this Chapter are not applied to bulk carriers which were contracted for construction after 1 April 2006 according to **Pt 13** (Common Structural Rules for Bulk Carriers and Oil Tankers). However, the requirements in **Sec 14** and **Sec 16** apply to bulk carriers including the vessels which should be applied **Pt 13**.
3. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.
4. The requirements in this Chapter are framed for ships not less than 100 m and up to 250 m in length and of usual form, having single deck, machinery aft, bilge hopper tanks and topside tanks, and also double bottoms under cargo holds, and decks and bottoms with longitudinal framing. In addition, SUBC(Self-Unloading Bulk Carrier), which has a hopper type cargo hold and a conveyor systemfor unloading cargo, is also subject to the requirements of this Chapter. *(2020)*
5. Ships with different construction from the scope of application given above or larger ships to which the requirements in this Chapter are not applicable, are to be at the discretion of the Society.
6. Bulk carriers, which were contracted for construction before 1 July 1998, and the keels of which were laid or which were at a similar stage of construction before 1 July 1999, are to be determined at the discretion of the Society.
7. All bulk carriers of 150 m in length and above, 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, which have the foremost hold stipulated in the following (1) or (2) and have not been constructed in compliance with **Sec 11** and **Sec 12** of the Rules are to be complied with **Annex 7-5 「Additional Requirements for Existing Bulk Carriers」**. *(2021)*
   (1) the foremost hold is bounded by the side shell only for ships which were contracted for construction prior to 1 July 1998.
   (2) 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.

102. Plans and documents for approval

Plans and documents submitted for approval are to indicate kinds of cargo and/or ballast, loading capacity, level of liquid, etc in each of the holds at service.

103. Direct strength calculation 【See Guidance】

Where approved by the Society, the scantlings of structural members may be determined based upon direct strength calculation specified in **Pt 3, Ch 1, 206.**

104. Drainage of bulk holds

1. In general, one bilge suction opening is to be arranged on each side of the ship at the after end of the each hold.
2. Bilge wells are to be arranged at suitable positions so as to protect the cover plates from the direct strike of bulk cargoes and to be provided with mud boxes or other suitable means so that the suction openings may not be choked by bulk dust, etc.
3. Where bilge pipes are led through double bottoms, side tanks or void spaces, non-return valves or stop valves capable of being closed from a readily accessible position, are to be provided at their

open ends.

4. Where scupper pipes on topside tanks are led over board, stop valves capable of being operated at deck and automatic non-return valves attached to shell plating are to be provided.

105. Coal transportation

For ships intended for transport of coal, care is to be taken to the following:
(1) Structure between holds and other compartments is to be airtight.
(2) Trimming hatches are recommended to be provided outside superstructures and deckhouses.
(3) Ventilation of holds is to be made by a ventilation system provided on the weather part.

106. Minimum thickness

1. The thickness of inner bottom plating, bulkhead plates, floor plates, girders and bracket plates in double bottom bilge hopper tanks, topside tanks, side tanks, hold tanks etc. are not to be less than those required by **Table 7.3.1** according to the length of ships.

Table 7.3.1 Minimum thickness

Length of ships(m)	Minimum thickness(mm)
$L < 105$	8.0
$105 \leq L < 120$	8.5
$120 \leq L < 135$	9.0
$135 \leq L < 150$	9.5
$150 \leq L < 165$	10.0
$165 \leq L < 180$	10.5
$180 \leq L < 195$	11.0
$195 \leq L < 225$	11.5
$225 \leq L < 275$	12.0
$275 \leq L < 325$	12.5
$325 \leq L < 375$	13.0
$375 \leq L$	13.5

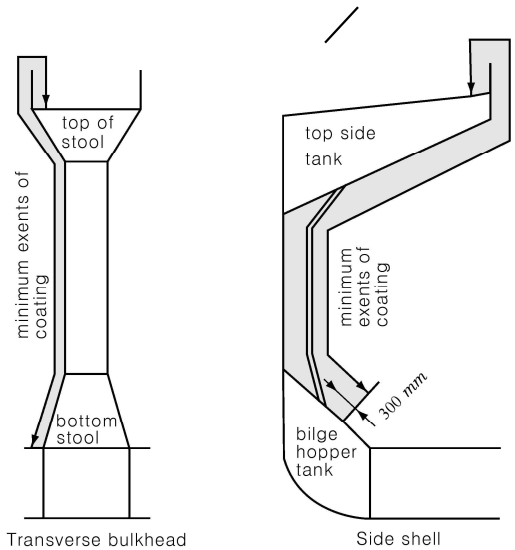


Fig 7.3.1 Minimum extent of corrosion protection coating for cargo hold

2. The minimum thickness of side shell plating located between hopper and upper wing tanks is not to be less than $t_{\min}$ in mm, given by :

$$t_{\min} = \sqrt{L} \quad (\mathrm{mm})$$

3. The minimum thickness of frame webs within the cargo area except the foremost cargo hold is not to be less than :

$$t_{\min} = 0.03L + 7 \quad (\mathrm{mm})$$

Where L is the length of ships (m), but need not be taken greater than 200 m. The thickness of the frame lower bracket is not to be less than the greater of the fitted thickness of the side frame web and $t_{\min} + 2\,(\mathrm{mm})$. The thickness of the frame upper bracket is not to be less than the greater of the fitted thickness of the side frame web and $t_{\min}$.

4. The minimum thickness of frame webs in way of the foremost hold is not to be less than 1.15 times of thickness as specified in **Par 3.** The thickness of the frame lower bracket in way of the foremost hold is not to be less than the greater of the fitted thickness of the side frame web and $1.15\,t_{\min}+2\,(\mathrm{mm})$. The thickness of the frame upper bracket is not to be less than the greater of the fitted thickness of the side frame web and $1.15\,t_{\min}$.

107. Corrosion protection coatings for cargo hold spaces

All internal and external surfaces of hatch coamings and hatch covers, and all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tankers sloping plating approximately 300 mm below the side shell frame and brackets, are to have an efficient protective coating (epoxy coating or equivalent) applied in accordance with the manufacturers recommendation.(See Fig **7.3.1**)

108. Longitudinal Strength

1. The longitudinal strength of bulk carriers is to comply with the requirements in **Pt 3, Ch 3.**

2. In addition to the requirements in **Par 1**, all bulk carriers of 150 m in length and above, intending to carry cargoes having bulk density of 1.0 $\mathrm{t/m^3}$, or above are to be in accordance with the requirements in **Sec 10.**

Section 2 Harmonised Notations and Corresponding Design Loading Conditions

201. General

1. General

A bulk carrier may in actual operation be loaded differently from the design loading conditions specified in the loading manual, provided limitations for longitudinal and local strength as defined in the loading manual and loading instrument onboard and applicable stability requirements are not exceeded.

2. Application

(1) The requirements are applicable to "Bulk Carrier" generally having single deck, double bottom, hopper side tanks and topside tanks, and with single or double side skin construction in cargo length area and intended primarily to carry dry cargoes in bulk and length as defined in **Pt. 3, Ch 1, 102.** of 150 m or above and contracted for new construction on or after 1 July 2003. *(2017)*

(2) The loading conditions listed under **Par 4** are to be used for the checking of rules criteria regarding longitudinal strength, local strength, capacity and disposition of ballast tanks and stability.

(3) The loading conditions listed under **Par 5** are to be used for the checking of rule criteria regarding local strength. The local strength is to be in accordance with the requirements of **Pt 3, Annex 3-2 Guidance for the Direct Strength Assessment.**

(4) For the purpose of applying the conditions given in the requirement, maximum draught is to be taken as moulded summer load line draught.

3. Harmonised notations and annotations

Bulk Carriers are to be assigned one of the following notations:

BC-A : for bulk carriers designed to carry dry bulk cargoes of cargo density of 1.0 $\mathrm{t/m^3}$ and above with specified holds empty at maximum draught in addition to BC-B conditions.

BC-B : for bulk carriers designed to carry dry bulk cargoes of cargo density of 1.0 $\mathrm{t/m^3}$ and above with all cargo holds loaded in addition to BC-C conditions.

BC-C : for bulk carriers designed to carry dry bulk cargoes of cargo density less than 1.0 $\mathrm{t/m^3}$.

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

(1) additional notations;

(max cargo density ... $\mathrm{t/m^3}$) for notations BC-A and BC-B if the maximum cargo density is less than 3.0 $\mathrm{t/m^3}$

(no MP) for all notations when the vessel has not been designed for loading and unloading in multiple ports in accordance with the conditions specified in **Par 5** (3).

(2) annotations;
(allowed combination of specified empty holds) for notation BC-A.

4. Design loading conditions (General)

(1) BC-C
Homogeneous cargo loaded condition where the cargo density corresponds to all cargo holds, including hatchways, being 100% full at maximum draught with all ballast tanks empty.

(2) BC-B
As required for BC-C, plus:
Homogeneous cargo loaded condition with cargo density 3.0 t/m^3, and the same filling rate (cargo mass/hold cubic capacity) in all cargo holds at maximum draught with all ballast tanks empty.
In cases where the cargo density applied for this design loading condition is less than 3.0 t/m^3, the maximum density of the cargo that the vessel is allowed to carry is to be indicated with the additional notation (max cargo density ... t/m^3).

(3) BC-A
As required for BC-B, plus:
At least one cargo loaded condition with specified holds empty, with cargo densit 3.0 t/m^3, and the same filling rate (cargo mass/hold cubic capacity) in all loaded cargo holds at maximum draught with all ballast tanks empty.
The combination of specified empty holds shall be indicated with the annotation (Holds Nos. ... may be empty).
In such cases where the design cargo density applied is less than 3.0 t/m^3, the maximum density of the cargo that the vessel is allowed to carry shall be indicated within the annotation, e.g. (Holds Nos. ... may be empty, with max cargo density ... t/m^3).

(4) Ballast conditions (applicable to all notations)

(A) Ballast tank capacity and disposition
All bulk carriers are to have ballast tanks of sufficient capacity and so disposed to at least fulfill the following requirements:

(a) Normal ballast condition
Normal ballast condition for the purpose of this requirement is a ballast (no cargo) condition where :

(i) the ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in the last paragraph of **Pt 3, Annex 3-1 3.** (1) (G) of the Guidance are to be complied with.

(ii) any cargo hold or holds adapted for the carriage of water ballast at sea are to be empty.

(iii) the propeller is to be fully immersed, and

(iv) the trim is to be by the stern and is not to exceed 0.015L, where L is the length between perpendiculars of the ship.

In the assessment of the propeller immersion and trim, the draughts at the forward and after perpendiculars may be used.

(b) Heavy ballast condition
Heavy ballast condition for the purpose of this Requirement is a ballast (no cargo) condition where :

(i) the ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in the last paragraph of **Pt 3, Annex 3-1 3.** (1) (G) of the Guidance are to be complied with.

(ii) at least one cargo hold adapted for carriage of water ballast at sea, where required or provided, is to be full,

(iii) the propeller immersion I/D is to be at least 60%, where
I = the distance from propeller centerline to the waterline
D = propeller diameter, and

(iv) the trim is to be by the stern and is not to exceed 0.015L, where L is the length between perpendiculars of the ship.

(v) the moulded forward draught in the heavy ballast condition is not to be less than the smaller of 0.03L or 8 m

(B) Strength requirements
All bulk carriers are to meet the following strength requirements :

(a) Normal ballast condition
(ⅰ) the structures of bottom forward are to be strengthened in accordance with the **Pt 3, Ch 4, Sec. 4 404.** against slamming for the condition of (A) (a) at the lightest forward draught.
(ⅱ) the longitudinal strength requirements are to be met for the condition of (A) (a) and
(ⅲ) in addition, the longitudinal strength requirements are to be met with all ballast tanks 100% full.

(b) Heavy ballast condition
(i) the longitudinal strength requirements are to be met for the condition of (A) (b)
(ii) in addition to the condition in (B) (b) (ⅰ), the longitudinal strength requirements are to be met under a condition with all ballast tanks 100% full and one cargo hold adapted and designated for the carriage of water ballast at sea, where provided, 100 % full, and
(iii)where more than one hold is adapted and designated for carriage of water ballast at sea, it will not be required that two or more holds be assumed 100% full simultaneously in the longitudinal strength assessment, unless such conditions are expected in the heavy ballast condition. Unless each hold is individually investigated, the designated heavy ballast hold and any/all restrictions for the use of other ballast hold(s) are to be indicated in the loading manual.

(5) Departure and arrival conditions
Unless otherwise specified, each of the design loading conditions defined in **4.** (1) to **4.** (4) is to be investigated for the arrival and departure conditions as defined below:
- Departure condition : with bunker tanks not less than 95% full and other consumables 100%
- Arrival condition : with 10% of consumables.

5. Design loading conditions (for local strength)

(1) Definitions
The maximum allowable or minimum required cargo mass in a cargo hold, or in two adjacently loaded holds, is related to the net load on the double bottom. The net load on the double bottom is a function of draft, cargo mass in the cargo hold, as well as the mass of fuel oil and ballast water contained in double bottom tanks. (Refer to **Annex 7-4 「Guidance for Calculating the Maximum Allowable and Minimum Required Mass of Cargo and Double Bottom Contents with Bulk Carriers」)** *(2021)*
The following definitions apply:
M_H : the actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught.
M_{Full} : the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1.0 t/m^3) filled to the top of the hatch coaming. M_{Full} is in no case to be less than M_H.
M_{HD} : the maximum cargo mass allowed to be carried in a cargo hold according to design loading condition(s) with specified holds empty at maximum draft.

(2) General conditions applicable for all notations
(A) Any cargo hold is to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at maximum draught.
(B) Any cargo hold is to be capable of carrying minimum 50% of M_H, with all double bottom tanks in way of the cargo hold being empty, at maximum draught.
(C) Any cargo hold is to be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at the deepest ballast draught.

(3) Conditions applicable for all notations, except when notation {no MP} is assigned
(A) Any cargo hold is to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of maximum draught.
(B) Any cargo hold is to be capable of being empty with all double bottom tanks in way of the cargo hold being empty, at 83% of maximum draught.
(C) Any two adjacent cargo holds are to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of the maximum draught. The requirement to the mass of cargo and fuel oil in double bottom tanks in way of the cargo hold applies also to the condition where the adjacent hold is filled with ballast, if applicable.

(D) Any two adjacent cargo holds are to be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at 75% of maximum draught.

(4) Additional conditions applicable for BC-A notation only

(A) Cargo holds, which are intended to be empty at maximum draught, are to be capable of being empty with all double bottom tanks in way of the cargo hold also being empty.

(B) Cargo holds, which are intended to be loaded with high density cargo, are to be capable of carrying M_{HD} plus 10% of M_H, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom being empty in way of the cargo hold, at maximum draught. In operation the maximum allowable cargo mass shall be limited to M_{HD}.

(C) Any two adjacent cargo holds which according to a design loading condition may be loaded with the next holds being empty, are to be capable of carrying 10% of M_H in each hold in addition to the maximum cargo load according to that design loading condition, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at maximum draught.

In operation the maximum allowable mass shall be limited to the maximum cargo load according to the design loading conditions.

(5) Additional conditions applicable for ballast hold(s) only Cargo holds, which are designed as ballast water holds, are to be capable of being 100% full of ballast water including hatchways, with all double bottom tanks in way of the cargo hold being 100% full, at any heavy ballast draught. For ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.

(6) Additional conditions applicable during loading and unloading in harbour only

(A) Any single cargo hold is to be capable of holding the maximum allowable sea-going mass at 67% of maximum draught, in harbour condition.

(B) Any two adjacent cargo holds are to be capable of carrying M_{Full}, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in he double bottom in way of the cargo hold being empty, at 67% of maximum draught, in harbour condition.

(C) A reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15% of the maximum mass allowed at the maximum draught in sea-going condition, but shall not exceed the mass allowed at maximum draught in the sea-going condition. The minimum required mass may be reduced by the same amount.

(7) Hold mass curves

Based on the design loading criteria for local strength, as given in preceding **5.** (2) to **5.** (6) (except **5.** (5)), hold mass curves are to be included in the loading manual and the loading instrument, showing maximum allowable and minimum required mass as a function of draught, in seagoing condition as well as during loading and unloading in harbour.

At other draughts than those specified in the preceding design loading conditions, the maximum allowable and minimum required mass is to be adjusted for the change in buoyancy acting on the bottom. Change in buoyancy is to be calculated using water plane area at each draught. Hold mass curves for each single hold, as well as for any two adjacent holds, are to be included.

Section 3 Double Bottoms

301. General 【See Guidance】

1. Except where required in this Section, the requirements in **Pt 3, Ch 7** are to be applied.

2. The scantlings of structural members in double bottom tanks intended to be deep tanks are to be correspondingly in accordance with the requirements in **Pt 3, Ch 15,** as well as the requirements in this Section. However, the thickness of inner bottom plating need not be increased by 1 mm as given in **Pt 3, Ch 15, 208.** for the top plating of deep tanks.

3. Specific gravity of cargoes described in this Section is as defined by the following formula :

$$\gamma = \frac{W}{V}$$

where:

W = mass of cargoes for the hold under consideration (t).

V = volume of the hold excluding its hatchway (m^3)

4. The coefficient specified in **302.** to **304.** is to be obtained from the following formula. Where, however, the angle between hopper plate and horizontal plane, β, is very large, the value of k is to be at the discretion of the Society. (See Fig **7.3.2**)

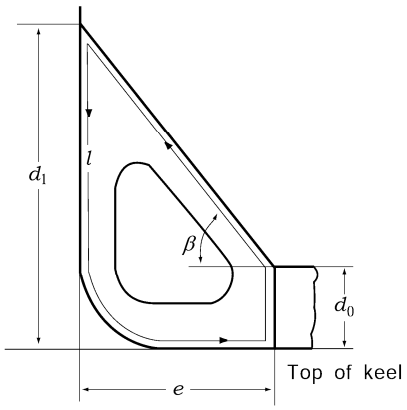


Fig 7.3.2 Measurement of l, e, d_0, d_1 etc.

$$k = 2.1\frac{l\,l_h}{e^2\left(1+\frac{d_1}{d_0}\right)^2}$$

where:

l_h = length of hold (m). Where stools are provided at transverse bulkheads, l_h may be reduced to the distance between the toes.

l = total girth length of hopper plate, side girder and shell plating composing the bilge hopper (m).

e = width of bilge hopper (m)

d_1 = distance from the top of keel to the top of bilge hopper (m).

d_0 = depth of centre girder (m).

5. In addition to the requirements in this **Sec**, all single side skin bulk carriers of 150 m in length and above, intending to carry cargoes having bulk density of 1.0 t/m^3 or above, are to be in accordance with the requirements in **Sec 11.**

302. Centre girders and side girders 【See Guidance】

1. Side girders are to be provided at the toes of bilge hoppers. In addition, side girders are to be arranged between the centre girder and the side girder at the toe of bilge hoppers at intervals approximately not exceeding the distance obtained from the given in **Table 7.3.2.** Where, however, the value given by the formula exceeds 4.6 m, the distance is to be taken as 4.6 m.
2. Except where specially approved by the Society, the thickness and depth of centre girders are not to be less than those obtained from the formula given in **Table 7.3.2.** In any case, however, the depth is not to be less than $B/20$.
3. Where duct keels are provided, their spacing is not to be larger than 1.8 m. Sufficient consideration is to be paid to strength continuity of solid floors and stiffness of shell plating and inner bottom plating between duct keels.
4. Where the distance from the top of inner bottom plating to the top of overflow pipes is more than 15 m, brackets are to be provided at both ends of vertical stiffeners on watertight side girders and to be connected with inner bottom plating and bottom longitudinals.

303. Floor plates 【See Guidance】

1. Solid floors are to be provided with spacing not more than that obtained from the formulae given in **Table 7.3.3.** However, the spacing is to be 3.65 m even if the value obtained exceeds 3.65 m, and the spacing may be 2.5 m where the value obtained is less than 2.5 m. Solid floors are to be provided at the foot of the sloping plates of lower stools attached to transverse bulkhead.
2. The thickness of solid floors is not to be less than that obtained from the formula given in **Table 7.3.3.**

304. Inner bottom plating

1. The thickness of inner bottom plating is not to be less than that obtained from the following formulae, whichever is the greater: 【See Guidance】

$$t_1 = C_3 \frac{KB^2 d}{d_0} + 1.5 \quad (\mathrm{mm})$$

$$t_2 = C_3' S \sqrt{hK} + 1.5 \quad (\mathrm{mm})$$

where:

d_0 = height of centre girders (mm).

S = spacing of inner bottom longitudinals (m).

h = vertical distance from the top of inner bottom plating to the upper deck at centre line (m).

C_3 = coefficient given by the following formula. However, for adjacent holds simultaneously loaded or empty, and specially short holds, the value obtained from the following formula is to be multiplied by 1.2 :

$$C_3 = ab$$

a = as specified in **Table 7.3.2.**

b = b_0 or αb_1 given below according to the value of B/l_h.

b_0 for $\frac{B}{l_h} < 0.8$

b_0 or αb_1, whichever is the greater for $0.8 \leq \frac{B}{l_h} < 1.2$

αb_1 for $1.2 \leq \frac{B}{l_h}$

b_0, b_1 = as given in **Table 7.3.4** according to the values of k and B/l_h.

k, l_h = as specified in **301. 4** respectively.

α = as given by the following formula :

$$\alpha = \frac{13.8}{24 - 10.6 f_B K}$$

C_3' = coefficient obtained from the following formulae, depending on the value of l/S :

$\left(0.46\frac{l}{S} + 2.64\right)\sqrt{\gamma}$ for $1 \leq \frac{l}{S} < 3.5$

$4.25\sqrt{\gamma}$ for $3.5 \leq \frac{l}{S}$

l = distance between floors (m).

γ = as specified in **301. 3.** However, the value of γ is not to be less than 1.2 times the ratio of the designed deadweight (t) to the total capacity of all holds (m^3).

2. The thickness of inner bottom plating under hatchway, where no ceiling is provided, is to be 2 mm greater than that obtained from the second formula in **Par 1,** except where **Par 3** is applied.

3. In ships in which cargoes are handled by grabs or similar mechanical appliances, thickness of inner bottom plating is to be 2.5 mm greater than that specified in **Par 1,** except where ceiling is provided.

305. Longitudinals 【See Guidance】

The section modulus of bottom and inner bottom longitudinals is not to be less than that obtained from the formulae given in **Table 7.3.5,** respectively.

Table 7.3.2 Dimension of centre girders and side girders

Item	Scantlings
(1) Spacing of side girders	(a) For loaded holds $l = 5.7 - 1.6\gamma$ (m)
	(b) For empty holds when the ship is fully loaded $l = 3.5$ (m)
(2) Depth of centre girders	$H = 15\sqrt{\frac{L_h BD}{m}}$ (mm)
(3) Thickness of centre girders and side girders	The thickness obtained from the following formula according to the location in the hold, whichever is the greater : $t_1 = \frac{C_1 KSB\,d}{d_0 - d_1}\left(2.6\frac{x}{l_h} - 0.17\right)\left\{1 - 4\left(\frac{y}{B}\right)^2\right\} + 1.5$ (mm) $t_2 = \frac{C_1'\,d_2}{1000\sqrt{K}} + 1.5$ (mm)

γ = as specified in **301. 3.**
L_h = total length of all cargo holds, excluding pump rooms and cofferdams (m).
m = number of holds
S = distance between the centres of two adjacent spaces from the centre or side girder under consideration to the adjacent longitudinal girders (m).
d_0 = depth of the centre or side girder under consideration (mm).
d_1 = depth of the opening at the point under consideration (mm).
d_2 = depth of the girder at the point under consideration (mm). Where, however, horizontal stiffeners are provided in way of the depth of girder, d_0 is the distance from the horizontal stiffener to the bottom shell plating or inner bottom plating or the distance between the horizontal stiffeners (mm).
l_h = length defined in **301. 4.**
x = longitudinal distance between the centre of l_h of each hold and the point under consideration (m). Where, however, x is less than $0.2\,l_h$, x is to be taken as $0.2\,l_h$, and where x exceeds $0.45\,l_h$, x may be taken as $0.45\,l_h$.
y = transverse distance from the centre line of ship to the longitudinal girder (m).
S_1 = spacing of the brackets or stiffeners provided on the centre girders or the side girders under consideration (m).
C_1' = coefficient given in the following table according to S_1/d_2. For intermediate values of S_1/d_2, C_1' is to be obtained by linear interpolation.

S_1/d_2	C_1'	
	Centre girder	Side girder
0.3 and under	4.4	3.6
0.4	5.4	4.4
0.5	6.3	5.1
0.6	7.1	5.8
0.7	7.7	6.3
0.8	8.2	6.7
0.9	8.6	7.0
1.0	8.9	7.3
1.2	9.3	7.6
1.4	9.6	7.9
1.6 and over	9.7	8.0

Table 7.3.2 Dimension of centre girders and side girders (continued)

C_1 = nab
n : coefficient given by the following table.

Location	n
For adjacent holds simultaneously loaded or empty, and specially short holds such as pump room located in the area of cargo holds	$\frac{1}{3}\left(7-2\frac{B}{l_h}\right)^{(*1)}$
For other holds	1.0

(*1) B/l_h exceeds 1.8, B/l_h is to be taken as 1.8, and where B/l_h is under 0.5, B/l_h is to be taken as 0.5.

a = coefficient given by the following table.

Position	$h\gamma/d$	a
For loaded holds	$\frac{h\gamma}{d} < 0.55$	$0.026\frac{L'}{d}-\frac{h\gamma}{d}+1$
	$0.55 \le \frac{h\gamma}{d} \le 1.45$	$0.026\frac{L'}{d}+0.45$
	$\frac{h\gamma}{d} > 1.45$	$0.026\frac{L'}{d}+\frac{h\gamma}{d}-1$
For empty holds under full load condition		$0.026\frac{L'}{d}+1$

h = vertical distance from the top of inner bottom plating to the upper deck at centre line (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
b = value given in the following table, depending on k and B/l_h specified in **301. 4.** For intermediate values of k, b is to be obtained by linear interpolation.

k \ B/l_h	and over less than 1.4	1.4 1.6	1.6 1.8	1.8 2.0	2.0 2.2	2.2 2.4	2.4
10.0 and over	17	16	15	14	13	12	11
5.0	16	15	14	13	12	11	11
2.0	15	15	14	13	12	11	11
1.0	14	14	14	13	12	11	11
0	13	13	13	12	12	11	11

NOTE :
Where a partial intermediate side girder with suitable thickness is provided at a location between a transverse bulkhead, or a stool in case where it is provided at the lower part of a bulkhead and the solid floor located at a position 20 % or more of the hold length far from the end of the hold, 35 % each of its sectional area of the intermediate side girder may be added to the sectional area of the adjacent girders respectively. Where a stool is provided at the lower part of a transverse bulkhead, a side girder is to be provided under the stool to counter-balance this partial intermediate side girder.

Table 7.3.3 Spacing and thickness of floor plates

Item	Scantlings
(1) Spacing of floor plates	(a) For loaded holds $l = 5.6 - 2.8\gamma$ (m)
	(b) For empty holds under full loaded condition $l = 2.5$ (m)
(2) Thickness of solid floors	The thickness obtained from the following formula according to the location in the hold, whichever is the greater: $t_1 = \frac{C_2 K S B' d}{d_0 - d_1}\left(\frac{2y}{B''}\right)\left\{1 - 2\left(\frac{x}{l_h}\right)^2\right\} + 1.5$ (mm) $t_2 = 0.086\sqrt[3]{\frac{H^2 d_0^2}{C_2' K}(t_1 - 1.5)} + 1.5$ (mm)

γ = as specified in **301. 3.**
S = spacing of solid floors (m).
B' = distance between the lines of bilge hoppers at the top of inner bottom plating at the midship part (m).
B'' = distance between the lines of toes of bilge hoppers at the top of inner bottom plating at the position of the solid floor under consideration (m).
l_h = length defined in **301. 4.**
y = transverse distance from the centre line of ship to the point under consideration at the position of the solid floor under consideration (m). Where, however, y is less than $B''/4$, y is to be taken as $B''/4$, and where y exceeds $B''/2$, y may be taken as $B''/2$.
x = longitudinal distance from the middle of l_h of the respective hold to the floor under consideration (m).
d_0 = depth of the solid floor at the point under consideration (mm).
d_1 = depth of the opening at the point under consideration (mm).
C_2 = coefficient obtained from the following table.

Position	C_2
For cargo hold	ab
For adjacent holds simultaneously loaded or empty	0.9 ab

a = coefficient specified in **Table 7.3.2.**
b = value given in the following table, according to k and B/l_h which are defined in **301. 4.** For intermediate values of k, the value of b is to be determined by linear interpolation

k \ B/l_h	and over less than 0.4	0.4 0.6	0.6 0.8	0.8 1.0	1.0 1.2	1.2 1.4	1.4 1.6	1.6 1.8	1.8 2.0	2.0 2.2	2.2 2.4	2.4
10.0 and over	40	38	34	31	26	23	21	18	16	15	14	12
5.0	40	40	37	33	30	26	24	22	18	18	16	15
2.0	41	40	38	35	33	30	28	25	23	21	18	17
1.0	41	40	40	39	37	34	32	29	26	24	23	21
0	41	41	41	41	41	40	37	33	32	30	26	25

C_2' = coefficient given in the following table, according to the ratio of the spacing of stiffeners S_1 (mm) to d_0. For intermediate values of S_1/d_0, C_2' is to be determined by linear interpolation.

S_1/d_0	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_2'	64	38	25	19	15	12	10	9	8	7

Table 7.3.3 Spacing and thickness of floor plates (continued)

H : value obtained from the following table.

Kinds	H
(a) Where slots without reinforcement are provided on solid floors	$\sqrt{4.0\frac{d_2}{S_1}-1.0}^{(*1)}$
(b) Where openings without reinforcement are provided on solid floors	$0.5\frac{\phi}{d_0}+1$
(c) Where slots and openings without reinforcement are provided on solid floors	Product of the values given by (a) and (b).
(d) Except for (a), (b) and (c)	1.0

(*1) Where d_2/S_1 is less than 0.5, H is to be taken as 1.0.

d_2 = depth of slots without reinforcement provided at the upper and lower parts of solid floors (mm), whichever is the greater.

ϕ = major diameter of the openings (mm).

NOTE :
Where a partial intermediate solid floor with suitable thickness is provided between the outermost side girder and the side girder located not less than 20% of B'' far from the former, 35% each of its sectional area may be added to the sectional area of the adjacent solid floors respectively. In this case, diaphragms, girders or brackets are to be provided in the bilge hopper tank to counter-balance this partial intermediate solid floor.

Table 7.3.4 Coefficient b_0 or b_1

B/l_h and over	B/l_h less than	k : b_0 or b_1	10.0 and over	5.0	2.0	1.0	0
	0.4	b_0	4.6	3.9	3.3	2.7	2.0
0.4	0.6	b_0	4.1	3.5	3.0	2.4	2.0
0.6	0.8	b_0	3.4	2.9	2.4	2.1	1.9
0.8	1.0	b_0	2.3	2.1	1.9	1.7	1.5
		b_1	2.3	2.0	1.7	1.4	1.4
1.0	1.2	b_0	1.7	1.5	1.5	1.4	1.3
		b_1	2.2	1.9	1.7	1.6	1.3
1.2	1.4	b_1	2.0	1.8	1.6	1.4	1.3
1.4	1.6	b_1	1.8	1.6	1.5	1.4	1.2
1.6	1.8	b_1	1.5	1.4	1.4	1.3	1.2
1.8	2.0	b_1	1.3	1.2	1.2	1.2	1.2
2.0	2.2	b_1	1.1	1.1	1.1	1.1	1.1
2.2		b_1	1.0	1.0	1.0	1.0	1.0

NOTE:
For intermediate values of k, b_0 and b_1 are to be obtained by linear interpolation.

Table 7.3.5 Section modulus of bottom and inner

<table>
<tr><td>Longitudinals</td><td colspan="2">Section modulus (cm^3)</td></tr>
<tr><td>Bottom longitudinals</td><td colspan="2">$Z_b = \frac{CKSl^2}{24-15.0f_BK}(d+0.026L')$</td></tr>
<tr><td>Inner bottom longitudinals</td><td colspan="2">$Z_i = \frac{CKShl^2}{24-11.4f_BK}$
(However, $Z_{min} = 0.75Z_b$)</td></tr>
<tr><td colspan="3">γ = as specified in 301. 3.
l = spacing of solid floors (m).
S = spacing of bottom longitudinals or inner bottom longitudinals (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.
h = as specified in 304.1.
C = coefficient given in the following table.</td></tr>
<tr><td rowspan="2">Case</td><td colspan="2">C</td></tr>
<tr><td>Bottom longitudinals</td><td>Inner bottom longitudinals</td></tr>
<tr><td>In case where no strut specified in 306. is provided midway between floors</td><td>100</td><td>100 γ
(However, $C \geq 90$)</td></tr>
<tr><td rowspan="3">In case where a strut specified in 307. is provided midway between floors</td><td>a) Lower part of the holds which be-come empty in a fully loaded condition and that of deep tanks: 62.5</td><td rowspan="2">60 γ
(However, $C \geq 54$)</td></tr>
<tr><td>b) Elsewhere: 30 γ + 20 (However, $C \geq 50$)</td></tr>
<tr><td colspan="2">And further, where the width of vertical stiffeners provided on floors and that of struts are specially large, the coefficient may be properly reduced.</td></tr>
</table>

306. Vertical struts

1. Where vertical struts are provided, they are to be rolled sections other than flat bars or bulb plates and to be well overlapped with the webs of bottom and inner bottom longitudinals.

2. The sectional area of the above-mentioned vertical struts is not to be less than that obtained from the following formula. Where the double bottom is deep, sufficient care is to be taken against buckling.

$$A = 1.8CKSbh \quad (cm^2)$$

where:

S = spacing of longitudinals (m).

b = breadth of the area supported by the strut (m).

h = as obtained from the following formula. In no case is h to be less than d.

$$h = \frac{d + 0.026L' + h_i}{2} \quad (\mathrm{m})$$

L' = as specified in **Table 7.3.2.**

h_i = γ times the value of h specified in **304. 1** (m). However, under deep tanks, h is not to be less than the vertical distance from the upper surface of inner bottom to the mid-point between the top of overflow pipe and the top of inner bottom or 0.7 times the vertical distance from the upper surface of inner bottom to the point of 2.0 metres above the top of overflow pipe, whichever is the greater (m).

γ = as specified in **301. 3.**

C = coefficient obtained from the following formula. In no case is the value of coefficient to be less than 1.43.

$$C = \frac{1}{1 - 0.5\frac{l_s}{k\sqrt{K}}}$$

l_s = length of strut (m).

k = minimum radius of gyration of vertical struts, obtained from the following formula (cm).

$$k = \sqrt{\frac{I}{A}}$$

I = the least moment of inertia of the strut (cm^4).

A = sectional area of the strut (cm^2).

307. Double bottom structure under lower stools at bulkheads

The inner bottom plating, centre girders, side girders and bottom longitudinals under lower stools at bulkheads are to be connected with those of holds just before and behind the bulkheads properly extending them. The floors are to be equivalent to those of holds.

Section 4 Hopper Tanks

401. General 【See Guidance】

1. Compartments of hopper tanks are to be in coincidence with those of holds as far as practicable.

2. Special care is to be taken for the continuity of strength at fore and aft ends of hopper tank structure.

3. The scantlings of structural members in hopper tanks are to be in accordance with the requirements in this Section and also those in **Pt 3, Ch 15.**

402. Thickness of hopper plates 【See Guidance】

1. The thickness of hopper plates of hopper tanks is not to be less than that obtained from the following formula.

$$t = CS\sqrt{hK} + 1.5 \quad (\mathrm{mm})$$

where:

S = length of the shorter side of the panel enclosed by stiffeners, etc. (m)

h = vertical distance from the lower end of the hopper plate to the upper deck at centre line (m).

C = coefficient obtained from the following formula. However, in no case is it to be less than 3.2.

$$C = 4.25\, C_1 C_2 \sqrt{\gamma}$$

C_1 = coefficient obtained from the following formula

where $1 \le \frac{l}{S} < 3.5$ $\quad C_1 = \left(0.11\frac{l}{S} + 0.615\right)$

where $3.5 \le \frac{l}{S}$ $\quad C_1 = 1$

l = length of the longer side of the panel enclosed by stiffeners, etc. (m)

C_2 = coefficient obtained from the formula in **Table 7.3.6.**

Table 7.3.6 Coefficient C_2

Angle β (degree)	C_2
$\beta \le 40^\circ$	1.0
$40^\circ < \beta < 80^\circ$	1.4 − 0.01 β
$\beta \ge 80^\circ$	0.6

γ = as specified in **301. 3.** However, in no case is the value of γ to be less than 1.2 times the ratio of the designed total cargo mass (t) to the total volume of all cargo holds (including hatchways) (m^3).

2. In ships in which cargoes are handled by grabs or similar mechanical appliances, the thickness of hopper plate is to be increased by following thickness above that determined in the preceding **1.** or determined by **401. 3,** whichever is the grater.

Hopper plate under hatchway---------- 2.5 mm

Hopper plate other than the above------ 1.0 mm

3. Where transverse stiffeners are provided on the hopper plates is to be sufficient against buckling.

403. Stiffeners

1. The section modulus of longitudinal stiffeners provided on the hopper plates is not to be less than that obtained from the following formula :

$$Z = CKShl^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of stiffeners (m).

h = vertical distance from the stiffener to the upper deck at centre line (m).

l = length of longitudinal stiffener between transverse webs (m).

C = coefficient obtained from the following formula:

$$C = \frac{\alpha}{24 - 15.0 f_B K \frac{y}{y_B}}$$

α = coefficient obtained from the formula given in **Table 7.3.7** according to β, acute angle between the hopper plate and the horizontal plate and γ specified in **301. 3.**

Table 7.3.7 Coefficient α

Angle β (degree)	α
$\beta \leq 40^\circ$	130 γ
$40^\circ < \beta < 80^\circ$	(214-2.1 β)γ
$\beta \geq 80^\circ$	46 γ

y = vertical distance from the neutral axis of transverse section of hull to the longitudinal stiffener concerned (m).

y_B = vertical distance from the neutral axis of transverse section of hull to the top of keel (m).

2. The section modulus of transverse stiffeners provided on hopper plates is not to be less than that obtained from the following formula :

$$Z = CKShl^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of transverse stiffeners (m).

l = distance between the supports of stiffeners (m).

h = vertical distance from the mid-point of l to the upper deck at centre line (m).

C = coefficient obtained from the formula given in **Table 7.3.8.** according to b, acute angle between the hopper plate and the horizontal plate and γ specified in **301. 3.**

Table 7.3.8 Coefficient C

Angle β (degree)	C
$\beta \leq 40^\circ$	7.8γ
$40^\circ < \beta < 80^\circ$	$(12.8 - 0.125b)\gamma$
$\beta \geq 80^\circ$	2.8γ

3. Bottom longitudinals in bilge hopper tanks are to be in accordance with the requirements in **Pt 3, Ch 7, 403.** Side longitudinals are to be in accordance with the requirements in **Pt 3, Ch 8, 401. 1,** in which case l in the formula is to be taken as the distance between transverse webs in meters. The section modulus of bilge longitudinals need not exceed that specified for bottom longitudinals.

404. Transverse webs

1. In hopper tanks, a transverse web or diaphragm is to be provided at every solid floor.
2. The scantlings of transverse webs provided on hopper plates are not to be less than those obtained from the formulae given in **Table 7.3.9.**
3. Flat bar stiffeners are to be provided on transverse webs or diaphragms at the positions through which longitudinals pass and tripping brackets are to be provided at a spacing of approximately 3 meters as well.

Section 5 Topside Tanks

501. General

1. Compartments of topside tanks are to be in coincidence with those of holds as fas as practicable. Except for the foremost hold, however, adjacent two compartments may be made one compartment.
2. Special care is to be taken for the continuity of strength at the fore and after ends of topside tank structure.
3. The scantlings of members in topside tanks are not to be less than those specified in **Pt 3, Ch 15,** where h is not to be less than a half of the breadth of tanks at midship section.
4. As for the flat bars used for longitudinal stiffeners, the ratio of the depth to the thickness is not to be greater than 15. As for longitudinals near the strength deck, the slenderness ratio is not to exceed 60 as far as possible at the midship part of the ships.

502. Thickness of sloping plates 【See Guidance】

1. The thickness of sloping plates of topside tanks is not to be less than that obtained from the following formula :

$$t = 4.6S\sqrt{kh} + 1.5 \quad \text{(mm)}$$

where:
S = spacing of longitudinal or transverse stiffeners (m).
h = distance from the lower edge of sloping plate to the top of over-flow pipe or a half of the breadth of topside tank at midship part, whichever is the greater (m).

2. Where transverse stiffeners are provided on the sloping plates of topside tanks, the thickness of sloping plates is to be sufficient against buckling.

Table 7.3.9 Scantlings of transverse webs

Transverse webs		Scantlings
(1) Webs	Depth	$l/5$ or 2.5 times the depth of slot for longitudinal stiffener, whichever is the greater.
	Thickness	The thickness obtained from the following formulae, whichever is the greater. $t_1 = 0.01 d_0 + 1.5 \quad (\mathrm{mm})$ $t_2 = \dfrac{C_1 K S h l}{d_0 - a} + 1.5 \quad (\mathrm{mm})$ within 0.2 l from ends $t_3 = 0.0502 \sqrt[3]{\dfrac{C_1 S h l S_1^2}{d_0 - a}} + 1.5 \quad (\mathrm{mm})$
(2) Section modulus		$Z = C_2 K S h l^2 \quad (\mathrm{cm}^3)$
(3) Face bars	Breadth	$d = 2.7\sqrt{d_0 l_1} \quad (\mathrm{mm})$
	Thickness	Above formulae t_1 or t_2, whichever is the greater.

d_0 = depth of transverse webs (mm).
a = depth of slots (mm). Where effective collar plates are provided within 0.25 l from each end of l, a may be modified depending on the size of collar plates, a may be taken as zero for 0.5 l at the middle part of l.
S = breadth of the area supported by transverse webs (m).
h = vertical distance from the mid-point of l to the upper deck at centre line (m).
l = overall length of transverse web (m). Where the transverse webs are connected with effective brackets at ends. l may be modified in accordance with the requirements in **Pt 3, Ch 1, 605.**
l_1 = distance between supports of transverse web (m). Where, however, effective tripping brackets are provided, they may be taken as supports.
S_1 = the spacing of stiffeners of transverse webs or depth of web (m), whichever is smaller.
C_1, C_2 = coefficient obtained from the formulae given in the following table according to β, acute angle between the hopper plate and the horizontal plane and γ specified in **301. 3.** Where γ is less than 0.7, γ is to be taken as 0.7.

Angle (β)	C_1 (*1)	C_2 (*2)
$\beta \le 40^\circ$	41.7 γ	7.1 γ
$40^\circ < \beta < 80^\circ$	(68.5 - 0.67 β) γ	(11.5 - 0.11 β) γ
$\beta \ge 80^\circ$	14.9 γ	2.7 γ

(*1) Where the value, C_1, obtained from the above formula is less than 27.8, C_1 is to be taken as 27.8.
(*2) Where the value, C_2, obtained from the above formula is less than 4.75, C_2 is to be taken as 4.75. Where an effective support is provided at the mid-point of girder, one-half of C_2 obtained from the above formula may be taken as C_2.

503. Stiffeners provided on sloping plates

1. The section modulus of longitudinal stiffeners provided on the sloping plates of topside tanks is not to be less than that obtained from the following formula :

$$Z = CKShl^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of longitudinal stiffeners (m).

h = vertical distance from the stiffener to the top of overflow pipe or one-half of the breadth of topside tank at midship part, whichever is the greater (m).

l = length of longitudinal stiffeners between transverse webs (m).

C = coefficient obtained from the following formula :

$$C = \frac{100}{24 - 15 f_D K \frac{y}{y_D}}$$

y_D = vertical distance from the neutral axis of transverse section of hull to the top of beams at side (m).

y = vertical distance from the neutral axis of transverse section of hull to the longitudinal stiffener concerned (m).

2. The section modulus of transverse stiffeners provided on the sloping plates of topside tanks is not to be less than that obtained from the following formula :

$$Z = 6.8KSh\,l^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of transverse stiffeners (m).

l = unsupported length of stiffener (m).

h = vertical distance from the mid-point of l to the top of overflow pipe or one-half of the breadth of topside tank at midship part, whichever is the greater (m).

504. Longitudinal beams

The section modulus of longitudinal beams in topside tanks is not to be less than that obtained from the requirement in **Pt 3, Ch 10, 303.** Where, h is the deck load ($\mathrm{kN/m^2}$) specified in **Pt 3, Ch 10, Sec 2** or one-half of the breadth of topside tank at midship part multiplied by 9.81, whichever is the greater (m).

505. Side frames

1. The section modulus of side longitudinals in topside tanks is not to be less than that obtained from the formula in **Pt 3, Ch 8, 401. 1,** taking l and h as follows :

l = distance between transverse webs (m).

h = as specified in **Pt 3, Ch 8, 401. 1,** but is not to be less than one-half of the breadth of topside tank at midship part (m).

2. Where transverse frames are provided on the side shell plating in way of topside tanks, the section modulus is not to be less than that obtained from the following formula :

$$Z = 6KSh\,l^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of frames (m).

l = vertical distance from the bottom of sloping plate of topside tank to the upper deck at side (m).

h = vertical distance from the mid-point of l to the point $d + 0.038L'$ above the top of keel, or one-half of the breadth of topside tank at midship part, whichever is the greater (m). Where, however, the value is less than $0.3\sqrt{L}$ (m), h is to be taken as $0.3\sqrt{L}$ (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

506. Transverse webs

1. Transverse webs or diaphragms are to be provided at a spacing not exceeding 5 m in topside tanks.
2. The scantlings of transverse webs are not to be less than those obtained from the formulae in **Table 7.3.10.**
3. Flat bar stiffeners are to be provided on transverse webs or diaphragms at the positions through which longitudinal frames or longitudinal stiffeners pass and brackets are to be provided at a spacing of approximately 3 m as well.
4. Where heavy cargoes are loaded on the deck, web plates or diaphragms are to be suitably reinforced.

507. Large topside tanks 【See Guidance】

1. Where topside tanks are large, special consideration is to be given to the structure such as providing longitudinal diaphragms at around the midpoint of the breadth of topside tanks.
2. The thickness of longitudinal diaphragms, where provided, is not to be less than that specified in **106.**, or that obtained from the following formula, whichever is the greater. However, value of f_D is not to be less 1.0.

$$t = 19.8S\sqrt{\frac{yf_D}{D}} + 1.5 \quad (\text{mm})$$

where:

S = spacing of longitudinals (m).

y = vertical distance from $D/2$ at midship section to the mid-point of panel between the stiffeners under consideration (m).

3. Where longitudinal stiffeners are provided on longitudinal diaphragms, depth of stiffeners is not to be less than $0.06l$, where l is the distance between the girders provided on the longitudinal diaphragms. Where longitudinal stiffeners are connected with tripping brackets at ends, depth of the stiffeners may be properly reduced.
4. Where transverse stiffeners are provided on longitudinal diaphragms, the thickness of longitudinal diaphragms is to be sufficient against buckling. The scantlings of the stiffeners are to be equivalent to those specified in **Pt 3.**

Table 7.3.10 Scantlings of transverse webs

Transverse webs		Scantlings
(1) Webs	Depth	(a) Where struts are provided at an intermediate position of transverse webs : l /6 (b) Elsewhere : l /5 or 2.5 times the depth of slots through which longitudinals pass, whichever is the greater.
	Thickness	The thickness obtained from the following formulae, whichever is the greater: $t_1 = 0.01 d_0 + 1.5 \quad (\mathrm{mm})$ $t_2 = 41.7 K \frac{Shl}{d_0 - a} + 1.5 \quad (\mathrm{mm})$ within 0.2 l from ends $t_3 = 0.174 \sqrt[3]{\frac{Shl S_1^2}{d_0 - a}} + 1.5 \quad (\mathrm{mm})$
(2) Section modulus		(a) Where struts are provided at an intermediate position of transverse webs: $Z = 3.57 KShl^2 \quad (\mathrm{cm}^3)$ (b) Elsewhere : $Z = 7.14 KShl^2 \quad (\mathrm{cm}^3)$
(3) Face bars	Breadth	$b = 2.7 \sqrt{d_0 l_1} \quad (\mathrm{mm})$
	Thickness	Above formulae t_1 or t_2, whichever is the greater.

d_0 = depth of transverse webs (mm).
a = depth of slots (mm). Where effective collar plates are provided within 0.25 l from each end of l, a may be modified depending on the size of collar plates. a may be taken as zero for 0.5 l at the middle part of l.
S = breadth of the area supported by transverse webs (m).
h = vertical distance from the midpoint of l to the top of overflow pipe, or a half of the breadth of topside tank, whichever is the greater (m)
l = overall length of transverse webs (m). Where a longitudinal diaphragm is provided at an intermediate position of transverse webs, l is to be the distance from the longitudinal diaphragm to the heel of bracket provided at the end of transverse webs (m). In any case where effective brackets are provided, l may be modified as specified in **Pt 3, Ch 1, 605.**
l_1 = distance between supports of transverse web (m). Where, however, effective tripping brackets are provided, they may be taken as supports.
S_1 = the spacing of stiffeners of transverse webs or depth of web (m), whichever is smaller.

Section 6 Transverse Bulkheads and Stools

601. Transverse bulkheads 【See Guidance】

1. The scantlings of structural members of transverse bulkheads are to be in accordance with the requirements in **Pt 3, Ch 15, Sec 2.** Where, however, in application of these requirements, h in the formulae is to be substituted by $0.36\gamma h'$, where γ is as specified in **301. 3.** Where, however, γ is less than 1.5, γ is to be taken as 1.5, and h' is to be in accordance with the following :

(1) In case of bulkhead platings, vertical distance from the lower edge of bulkhead plate to the upper deck at centre line of ship (m).

(2) Vertical distance from the mid-point of l for vertical stiffeners on bulkhead or from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners to the upper deck at centre line of ship (m). l is as specified in **Pt 3, Ch 15, 203.**

(3) Vertical distance from the mid-point of l for vertical webs supporting stiffeners or from the midpoint of S for horizontal girders to the upper deck at centre line of ship (m). l and S are as specified in **Pt 3, Ch 15, 204.**

2. Notwithstanding the requirements in **Par 1**, the scantlings of structural members of transverse bulkheads are not to be less than those specified in **Pt 3, Ch 14.**

3. For transverse bulkhead without lower stool, the thickness of the lowest strake of bulkhead plating is to be appropriately increased referring to the thickness of inner bottom plating.

4. Plating of transverse bulkheads to which the sloping plates of topside tanks are connected, is to be properly strengthened, by increasing its thickness, or by any other means.

5. In addition to the requirements in this **Sec,** any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, and of single side or double side skin construction, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, with vertically corrugated transverse watertight bulkheads, which are contracted for construction on or after 1 July 2006 is to be in accordance with the requirements in **Sec 12.**

602. Lower and upper stools at transverse bulkheads

1. The thickness of hopper plate of the lower stool of transverse bulkhead is not to be less than that obtained from the formula in **402. 1.** using the value of coefficient C reduced by 10 %. In ships in which cargoes are handled by grabs or similar mechanical appliances, the thickness is to be increased by 1 mm.

2. The section modulus of horizontal stiffeners provided on sloping plates of lower stool is not to be less than that obtained from the formula for stiffeners or hopper plates given in **403. 1,** where the coefficient C of the first term is to be reduced by 10 %. Where vertical stiffeners are provided, the section modulus is not to be less than that specified in **403. 2.**

3. Girders are to be provided in lower stools in the positions of centre girders and side girders in double bottoms. Scantlings of girders are not to be less than those specified in **404.**

4. Where holds are so designed as to be loaded with ballast water, cargo oil or heavy cargo, girders specified in the preceding Paragraph are to be sufficient against shear, for instance, by adopting diaphragms.

5. The scantlings of the members of upper stools are not to be less than those specified in **Pt 3, Ch 14.**

6. In addition to the requirements in this **Sec,** any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, and of single side or double side skin construction, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, with vertically corrugated transverse watertight bulkheads, which are contracted for construction on or after 1 July 2006 is to be in accordance with the requirements in **Sec 12.**

Section 7 Hold Frames

701. Hold frames

1. The section modulus of hold frames is not to be less than that obtained from the formulae given in **Table 7.3.11.**

2. The thickness of webs near the top and bottom end connections of hold frames is to be sufficient against shearing.

3. For holds loaded with cargoes of specially large specific gravity, special care is to be taken such as increasing scantlings of hold frames specified in **Pars 1** and **2.**

4. Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

5. In ships less than 190 m in length, mild steel frames may be asymmetric and fitted with separate brackets. The face plate or flange of the bracket is to be sniped at both ends. Brackets are to be arranged with soft toes.

6. The side frame flange is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature is not to be less than r, given by : (See, Fig **7.3.4**)

$$r = \frac{0.4 b_f^2}{t_f} \quad (\mathrm{mm})$$

b_f = flange width of the brackets (mm).

t_f = thickness of the brackets (mm).

7. The web depth to thickness ratio of frames is not to exceed the following values.

(1) Symmetrical flanged frames : $60\sqrt{K}$

(2) Asymmetrical flanged frames : $50\sqrt{K}$

K is the material factor, as specified in **Pt 3, Ch 1, Sec 4, Table 3.1.3.**

8. The outstanding flange is not to be exceed $10\sqrt{K}$ times the flange thickness.

7.3.11 Section modulus of hold frames

Location	Section modulus (cm^3)
Between 0.15L from the fore end and the after peak bulkhead	$Z = CKShl^2$
Between 0.15L from the fore end and the collision bulkhead	$Z = 1.25KCShl^2$

S = spacing of frames (m).

h = vertical distance from a point $d + 0.038L'$ above the top of keel to the top of bilge hopper at side (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

l = distance between the top of bilge hopper at side and the bottom of top side tank (m). (See Fig **7.3.3**).

C = coefficient obtained from the following formula:

$$C = \left(3.3 - 2.5\frac{l}{h}\right) + (25.7\lambda_1 + 44.5)\alpha\frac{d}{h}$$

$$\lambda_1 = \frac{l_1}{l}$$

l_1 = vertical distance from the mid-point of depth of centre girder to the top of bilge hopper at side (m). (See Fig **7.3.3**)

α = coefficient given in the following table. For intermediate values of B/l_h the values of α are to be determined by linear interpolation. For the holds which are empty in fully loaded condition, the value of α is to be 1.8 times the value determined from the table.

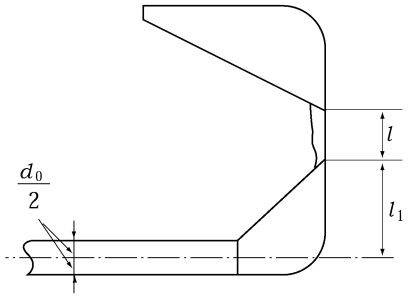


Fig 7.3.3 Measurement of l, l_1, etc

B/l_h	α
0.4 and under	0.0288
0.6	0.0207
0.8	0.0144
1.0	0.0099
1.2	0.0069
1.4	0.0048
1.6	0.0034
1.8 and over	0.0025

702. Top and bottom end connections of frames 【See Guidance】

1. The toes of brackets connecting frames with hopper plates and topside tank sloping plates are not to coincide with bracket ends in the tanks.

2. The section modulus of the frame and bracket or integral bracket, and associate shell plating, at the locations shown in Fig **7.3.4,** is not to be less than twice the section modulus required for the frame midspan area. The dimensions of the lower and upper brackets are not to be less than those shown in Fig **7.3.6.**

3. Structural continuity with the upper and lower end connection of side frames is to be ensured within topside and hopper tanks by connecting brackets as shown in Fig **7.3.5.** The brackets are to be stiffened against buckling.

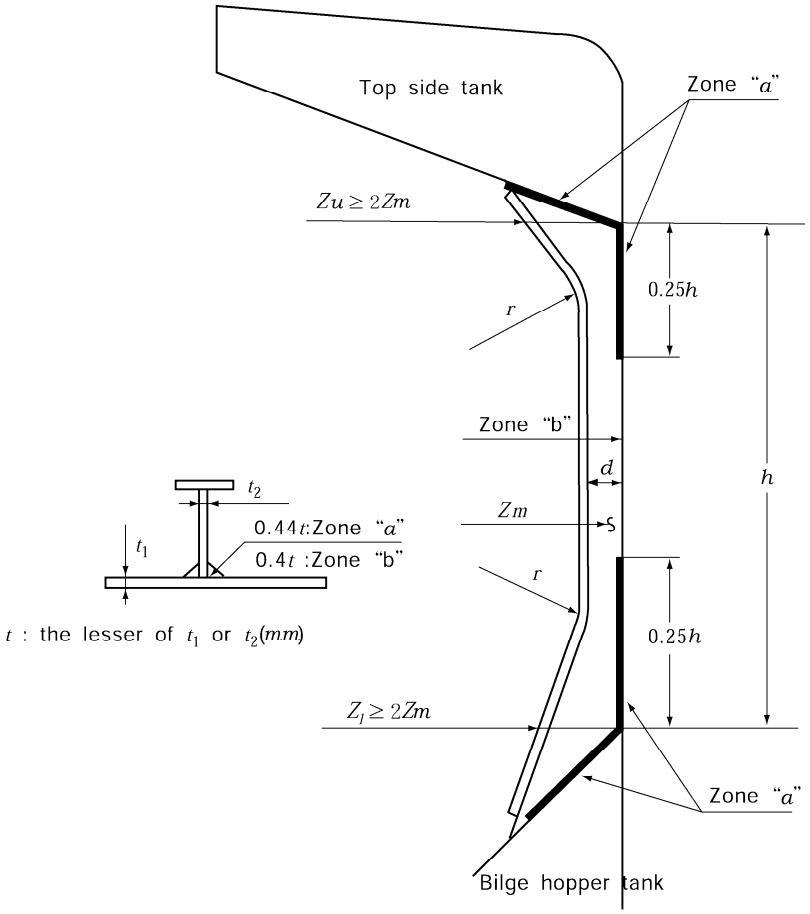


Fig 7.3.4 Figure of frame and bracket

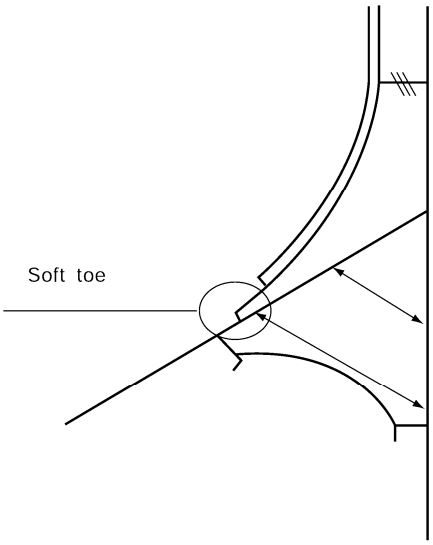
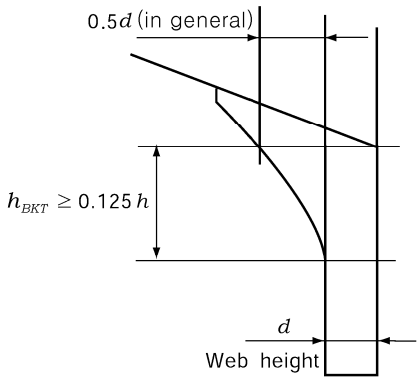


Fig 7.3.5 Bracket



h : As shown in **Fig 7.3.4**

Fig 7.3.6 The dimension of the lower and upper brackets.

4. Double continuous welding is to be adopted for the connections of frames and brackets to side shell, hopper and hopper wing tank plating and web to face plate. For this purpose, the weld throat is to be : (See, Fig **7.3.4**)

Zone "a" : 0.44 t, Zone "b" : 0.4 t,

Where, t is the thinner of the two connected members.

5. Where the hull form is such to prohibit an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated in **Par 4.**

703. Side structure in the foremost hold

The scantlings of side hold frames immediately adjacent to the collision bulkhead are to be increased in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures are to be fitted which maintain the continuity of forepeak stringers within the foremost hold.

704. Tripping brackets

In way of the foremost hold, side frames of asymmetrical section art to be fitted with tripping brackets at every two frames, as shown in Fig **7.3.7.**

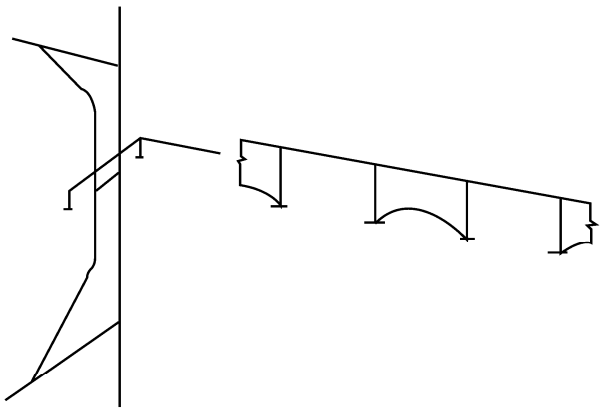


Fig 7.3.7 Tripping brackets to be fitted in way of foremost hold

Section 8 Decks and Shell Platings

801. Deck plating outside the line of openings 【See Guidance】

The cross sectional area of deck plating outside the line of openings, where topside tanks are not provided, is to determined in consideration of the continuity of longitudinal strength.

802. Deck plating inside the line of openings 【See Guidance】

1. Hatch end coamings are to be provided in coincidence with the positions of girders in topside tanks. If not coincident, sufficient care is to be taken for the continuity of strength at the connection of hatch end coamings with topside tanks.
2. Deck plating inside the line of openings is recommended to be provided with transverse beams. Where longitudinal beams are provided, special care is to be taken against buckling.

803. Side shell plating

Where a loaded hold and an empty hold are adjacent to each other across a transverse bulkhead, the thickness of side shell plating may be properly reduced from that specified in **Pt 3, Ch 3, 301.** considering that the transverse bulkhead under consideration withstands a part of shear forces on ship s hull in still water.

804. Bottom shell plating

The thickness of bottom shell plating of cargo holds in way of double bottom is not to be less than that obtained from the formula in **Pt 3, Ch 4, 304.** or from the first formula in **304. 1,** whichever is the greater. However, in application of the latter formula, α is to be as given by the following formula :

$$\alpha = \frac{13.8}{24 - 15.0 f_B K}$$

Section 9 Hatch Covers and Hatch Coamings of Cargo Holds

901. Application and definitions

1. These requirements apply to all bulk carriers, SUBC(Self-Unloading Bulk Carrier), ore carriers and combination carriers, and are for all cargo hatch covers and hatch forward and side coamings on exposed decks in position Ⅰ, as defined in **Pt 4, Ch 2, Sec. 1 102.** These requirements applies to ships contracted for construction on or after 1 January 2004. *(2020)*

2. The strength requirements are applicable to hatch covers and hatch coamings of stiffened plate construction.

3. 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 sufficient load carrying capacity.

4. 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.

5. These requirements are in addition to the requirements of the ICLL.

6. The net minimum scantlings of hatch covers are to fulfil the strength criteria of the followings where adopting the load model given in **902.** :

(1) **903. 3**, for plating,
(2) **903. 4**, for secondary stiffeners,
(3) **903. 5** for primary supporting members,
(4) **903. 6** the critical buckling stress,
(5) **903. 7** the rigidity criteria.

7. The net minimum scantlings of hatch coamings are to fulfil the strength criteria of the followings where adopting the load model given in **904. 1**:

(1) **904. 2** for plating,
(2) **904. 3** for secondary stiffeners,
(3) **904. 4** for coaming stays,

8. The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the minimum net scantlings required by **903.** and **904.**

The required gross thicknesses are obtained by adding the corrosion additions, t_s, given in **906.** to t_{net}.

9. Material for the hatch covers and coamings is to be steel according to **Pt 3, Ch 1, Sec. 4.**

10. Where t_{net} are used for member scantlings, they are to be noted on the drawings.

902. Hatch cover load model

1. The pressure P, in $\mathrm{kN/m^2}$, on the hatch covers panels is given as follows.

Table 4.2.3 Wave pressures on hatch covers

Ware Pressure P ($\mathrm{kN/m^2}$)			
Length for freeboard, L_f	Location	Position I	Position II
$L_f \geq 100$ m	$0.75 < x/L_f < 1$	$34.3+(14.8+a(L_f-100))(4\frac{x}{L_f}-3)$	
	$0 \leq x/L_f \leq 0.75$	34.3	25.5
$L_f < 100$ m	$0.75 < x/L_f < 1$	$12.2+\frac{L_f}{9}(5\frac{x}{L_f}-2)+3.6\frac{x}{L_f}$	
	$0 \leq x/L_f \leq 0.75$	$14.9+0.195L_f$	$11.3+0.142\,L_f$

Note
(1) a : coefficient taken equal to :
a = 0.0726 for Type B freeboard ships
a = 0.356 for Type B-60 or Type B-100 freeboard ships.
(2) L_f : Length for freeboard defined in **Pt 3, Ch 1, Sec 1** (m). But need not be taken greater than 340 m.
(3) x(m) : Distance from the end of stern to the center of hatch cover that should be considered.
(4) Where two or more panels are connected by hinges, each individual panel is to be considered separately.

903. Hatch cover strength criteria

1. Allowable stress checks

(1) 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 ($\mathrm{N/mm^2}$), given by:

$$\sigma_a = 0.80\sigma_y$$
$$\tau_a = 0.46\sigma_y$$

where,

σ_y = being the minimum upper yield stress ($\mathrm{N/mm^2}$), of the material.

(2) 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 **903. 6.**
(3) 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 FEM analysis.
(4) 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.
(5) When calculating the stresses σ and τ, the net scantlings are to be used.

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

The effective flange area A_f ($\mathrm{cm^2}$), 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:

$$A_f = \sum_{nf}(10b_{ef}t) \quad (\mathrm{cm^2})$$

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 (mm)
b_{ef} = effective breadth (m) of attached plate flange on each side of girder web
= b_p, but not to be taken greater than 0.165 l
b_p = half distance (m) between the considered primary supporting member and the adjacent one
l = span (m) of primary supporting members

3. Local net plate thickness

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

$$t = 15.8 F_p S \sqrt{\frac{P}{0.95\sigma_y}} \quad (\text{mm})$$

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

where,
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 (m)
p = pressure (kN/m^2) as defined in **902.**
σ = as defined in **903. 5.**
σ_a = as defined in **903.1**.
σ_y = as defined in **903.1**.

4. Net scantlings of secondary stiffeners

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

$$Z = \frac{1000\, l^2 SP}{12\sigma_a} \quad (\text{cm}^3)$$

where,
l = secondary stiffener span (m), to be taken as the spacing, 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 (m)
p = pressure (kN/m^2) as defined in **902.**
σ_a = as defined in **903. 1**

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

5. Net scantlings of primary supporting members

(1) 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 **903. 1.**
(2) 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.

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

6. Critical buckling stress check

(1) Hatch cover plating

(A) 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:

$$\sigma_{C1} = \sigma_{E1} \qquad \text{when } \sigma_{E1} \leq \frac{\sigma_y}{2}$$

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

where,

σ_y = minimum upper yield stress $(\mathrm{N/mm^2})$, of the material

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

E = modulus of elasticity $(\mathrm{N/mm^2})$
= 2.06 x 10^5 $(\mathrm{N/mm^2})$ for steel

t = net thickness (mm) of plate panel

S = spacing (m) of secondary stiffeners

(B) 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:

$$\sigma_{C2} = \sigma_{E2} \qquad \text{when } \sigma_{E2} \leq \frac{\sigma_y}{2}$$

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

where,

σ_y = minimum upper yield stress $(\mathrm{N/mm^2})$ of the material

$\sigma_{E2} = 0.9\, m\, E\left(\frac{t}{1000\, S_s}\right)^2$

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

E = modulus of elasticity $(\mathrm{N/mm^2})$
= 2.06 x 10^5 for steel

t = net thickness (mm) of plate panel

S_s = length (m) of the shorter side of the plate panel

l_s = length (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
= 1.21 when plating is stiffened by secondary stiffeners of angle or T type
= 1.1 when plating is stiffened by secondary stiffeners of bulb type
= 1.05 when plating is stiffened by flat bar

(C) The biaxial compressive stress in the hatch cover panels, when calculated by means of FEM shell element model, is to be in accordance with the satisfaction of the Society as deemed equivalent to the above criteria.

(2) Hatch cover secondary stiffeners

(A) 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:

$$\sigma_{CS} = \sigma_{ES} \quad \text{when} \quad \sigma_{ES} \leq \frac{\sigma_y}{2}$$

$$= \sigma_y \left[1 - \frac{\sigma_y}{4\sigma_{ES}}\right] \quad \text{when} \quad \sigma_{ES} > \frac{\sigma_y}{2}$$

where,

σ_y = minimum upper yield stress $(\mathrm{N/mm^2})$, of the material

σ_{ES} = ideal elastic buckling stress $(\mathrm{N/mm^2})$, of the secondary stiffener

= minimum between σ_{E3} and σ_{E4}

$$\sigma_{E3} = \frac{0.001\,EI_a}{Al^2}$$

E = modulus of elasticity $(\mathrm{N/mm^2})$

= 2.06×10^5 for steel

I_a = moment of inertia $(\mathrm{cm^4})$ of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners

A = cross-sectional area $(\mathrm{cm^2})$ of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners

l = span (m) of the secondary stiffener

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

$$K = \frac{Cl^4}{\pi^4 EI_w} \times 10^6$$

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

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

I_w = sectorial moment of inertia $(\mathrm{cm^6})$, of the secondary stiffener about its connection with the plating

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

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

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

I_p = polar moment of inertia $(\mathrm{cm^4})$, of the secondary stiffener about its connection with the plating

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

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

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

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

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

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

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

C = spring stiffness exerted by the hatch cover top plating

$= \frac{k_p \ E \ t_p^3}{3S \left(1 + \frac{1.33 k_p \ h_w \ t_p^3}{1000 S t_w^3} \right)} \times 10^{-3}$

S = spacing (m), of secondary stiffeners

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

η_p = $\frac{\sigma}{\sigma_{E1}}$

σ = as defined in **903. 5**

σ_{E1} = as defined in **903. 6** (1)

t_p = net thickness (mm) of the hatch cover plate panel

(B) For flat bar secondary stiffeners and buckling stiffeners, the ratio h / t_w is to be not greater than $15 \ k^{0.5}$,

where:

h / t_w = height and net thickness of the stiffener, respectively

k = $235 / \sigma_y$

σ_y = minimum upper yield stress ($\mathrm{N/mm^2}$) of the material.

(3) Web panels of hatch cover primary supporting members

(A) 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.

(B) 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:

$\tau_C = \tau_E$ when $\tau_E \leq \frac{\tau_F}{2}$

$= \tau_F \left[1 - \frac{\tau_F}{4\tau_E} \right]$ when $\tau_E > \frac{\tau_F}{2}$

where,

τ_F = $\frac{\sigma_y}{\sqrt{3}}$

σ_y = minimum upper yield stress ($\mathrm{N/mm^2}$) of the material

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

E = modulus of elasticity $(\mathrm{N/mm^2})$
= 2.06×10^5 for steel

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

k_t = $5.35 + \frac{4.0}{(a/d)^2}$

a = greater dimension (m) of web panel of primary supporting member

d = smaller dimension (m) of web panel of primary supporting member.

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

(D) 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.

7. Deflection limit and connections between hatch cover panels

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

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

8. Primary supporting members of variable cross-section

The net section modulus of primary supporting members with a variable cross-section is to be not less than the greater of the value obtained from the following formulae and the use of these formulae is limited to the determination of the strength of primary supporting members in which abrupt changes in the cross-section do not occur along their length. :

$$Z = Z_{CS} \quad (\mathrm{cm^3})$$

$$Z = (1 + \frac{3.2\alpha - \psi - 0.8}{7\psi + 0.4}) Z_{CS} \quad (\mathrm{cm^3})$$

Z_{CS} : Net section modulus calculated with considering the net thickness $(\mathrm{cm^3})$ for a constant cross-section, complying with the checking criteria in **903. 6 (3)**.

$$\alpha = \frac{l_1}{l_0}$$

$$\psi = \frac{Z_1}{Z_0}$$

l_1 : Length of the variable section part (m) (see the following figure.)

l_0 : Span measured, in m, between end supports (see the following figure.)

Z_1 : Net section modulus calculated with considering the net thickness at end $(\mathrm{cm^3})$ (see the following figure.)

Z_0 : Net section modulus calculated with considering the net thickness at mid-span $(\mathrm{cm^3})$ (see the following figure.)

Moreover, the net moment of inertia of primary supporting members with a variable cross-section calculated with considering it's net thickness is to be not less than the greater of the values obtained, in $\mathrm{cm^4}$, from the following formulae :

$$I = I_{CS} \quad (\mathrm{cm}^4)$$

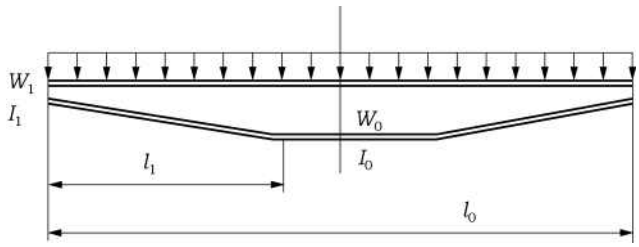
$$I = \left\{1 + 8\,\alpha^3\left(\frac{1-\phi}{0.2+3\sqrt{\phi}}\right)\right\} I_{CS} \quad (\mathrm{cm}^4)$$

I_{CS} : Net moment of inertia with a constant cross-section calculated with considering the net thickness (cm^4), complying with **903. 7** (2)

$$\phi = \frac{I_1}{I_0}$$

I_1 : Net moment of inertia calculated with considering the net thickness at end with considering the net thickness (cm^4) (see the following figure.)

I_0 : Net moment of inertia calculated with considering the net thickness at mid-span with considering the net thickness (cm^4) (see the following figure.)



Variable cross-section stiffener

9. Buckling stiffeners on webs of primary supporting members

For buckling stiffeners on webs of primary supporting members, the ratio h_w/t_w is to comply with the following formulae :

$$\frac{h_w}{t_w} \le 15\sqrt{\frac{235}{\sigma_y}}$$

h_w : Web height of the stiffener (mm)

t_w : Net thickness of the stiffener (mm)

904. Hatch coamings and local details

1. Load model

The pressure $P_{coam}\,(\mathrm{kN/m^2})$ on the No. 1 forward transverse hatch coaming is given by:

$P_{coam} = 220$, where there is a forecastle to which l_F according to **Sec. 13** is applied
$= 290$ in the other cases

The pressure $P_{coam}\,(\mathrm{kN/m^2})$ on the other coamings is given by:

$$P_{coam} = 220$$

2. Local net plate thickness

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

$$t = 14.9\,S\sqrt{\frac{P_{coam}}{\sigma_{a,coam}}S_{coam}}$$

where,

S = secondary stiffener spacing, in m

P_{coam} = pressure $(\mathrm{kN/m^2})$ as defined in **904. 1**

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

$\sigma_{a,coam}$ = $0.95\sigma_y$

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

3. Net scantlings of longitudinal and transverse secondary stiffeners

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

$$Z = \frac{1000\,S_{coam}\,l^2\,SP_{coam}}{m\,c_P\,\sigma_{a,coam}}$$

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 (m) of secondary stiffeners

S = spacing (m) of secondary stiffeners

P_{coam} = pressure $(\mathrm{kN/m^2})$ as defined in **904. 1**

c_P = ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth (mm), equal to $40\,t$, where t is the plate net thickness

= 1.16 in the absence of more precise evaluation,

$\sigma_{a,coam}$ = $0.95\sigma_y$

4. Net scantlings of coaming stays

(1) The required minimum section modulus, $Z(\mathrm{cm^3})$, and web thickness, $t_w(\mathrm{mm})$ of coamings stays designed as beams with flange connected to the deck or sniped and fitted with a bracket (see Fig **7.3.8** and **7.3.9**) at their connection with the deck, based on member net thickness, are given by:

$$Z = \frac{1000\,H_C^2\,S\,P_{coam}}{2\,\sigma_{a,coam}}$$

$$t_w = \frac{1000\,H_C\,SP_{coam}}{h\;\tau_{a,coam}}$$

where,

H_C = stay height (m)

S = stay spacing (m)

h = stay depth (mm) at the connection with the deck

P_{coam} = pressure $(\mathrm{kN/m^2})$ as defined in **904. 1**

$\sigma_{a,coam}$= $0.95\sigma_y$

$\tau_{a,coam}$= $0.5\sigma_y$

(2) 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.

(3) For other designs of coaming stays, such as, for examples, those shown in Fig **7.3.10** and **7.3.11**, the stress levels in **903. 1** are to be applied and checked at the highest stressed locations.

5. Local details

(1) The design of local details is to be determined at the discretion of with the Society for the purpose of transferring the pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below.
(2) Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.
(3) Underdeck structures are to be checked against the load transmitted by the stays, adopting the same allowable stresses specified in **904. 4**
(4) Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society requirements.
(5) 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.
(6) 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.

905. Closing arrangements

1. Securing devices 【See Guidance】

The strength of securing devices is to comply with the following requirements:
(1) Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.
(2) 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.
(3) The net sectional area of each securing device is not to be less than:

$$A = 1.4\,a/f \quad (\mathrm{cm}^2)$$

where,
a = spacing (m) of securing devices, not being taken less than 2 m
$f = (\sigma_y / 235)^e$
σ_y = specified minimum upper yield stress ($\mathrm{N/mm^2}$), of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.
$e = 0.75$ for $\sigma_y > 235\,(\mathrm{N/mm^2})$
$= 1.0$ for $\sigma_y \leq 235\,(\mathrm{N/mm^2})$

(4) Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 $\mathrm{m^2}$ in area.
(5) Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weather tightness is to be maintained by the securing devices.
(6) 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.
(7) 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:

$$I = 6pa^4 \quad (\mathrm{cm}^4)$$

where:
p = packing line pressure ($\mathrm{N/mm}$), minimum 5 $\mathrm{N/mm}$
a = spacing (m) of securing devices.

(8) 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.
(9) Where rod cleats are fitted, resilient washers or cushions are to be incorporated.
(10) 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.

2. Stoppers

(1) Hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 $\mathrm{kN/m^2}$.
(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 $\mathrm{kN/m^2}$.
(3) 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 $\mathrm{kN/m^2}$, but this pressure may be reduced to 175 $\mathrm{kN/m^2}$ where there is a forecastle to which l_F according to **Sec. 13** is applied.
(4) The equivalent stresses in stoppers and their supporting structures, and calculated in the throat of the stopper welds are not to exceed the allowable value of $0.8\,\sigma_y$.

3. Materials and welding

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

906. Corrosion addition and steel renewal

1. Hatch covers

(1) For all the structure (plating and secondary stiffeners) of single skin hatch covers, the corrosion addition t_s is to be 2.0 mm.
(2) 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.

(3) 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 $t_{net}+0.5\,\mathrm{mm}$.
(4) Where the gauged thickness is within the range $t_{net}+0.5\,\mathrm{mm}$ and $t_{net}+1.0\,\mathrm{mm}$, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.
(5) Coating is to be maintained in GOOD condition, as defined in **Pt 1, Ch 2, Sec. 1. 19.**
(6) 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's 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}.

2. Hatch coamings

(1) For the structure of hatch coamings and coaming stays, the corrosion addition t_s is to be 1.5 mm
(2) Steel renewal is required where the gauged thickness is less than $t_{net}+0.5\,\mathrm{mm}$.
(3) Where the gauged thickness is within the range $t_{net}+0.5\,\mathrm{mm}$ and $t_{net}+1.0\,\mathrm{mm}$, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.
(4) Coating is to be maintained in GOOD condition, as defined in **Pt 1, Ch 2, Sec. 1, 19.**

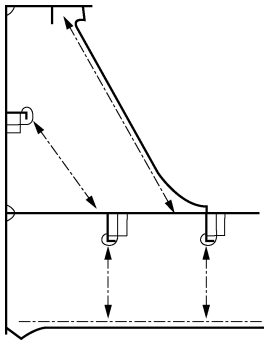


Fig 7.3.8

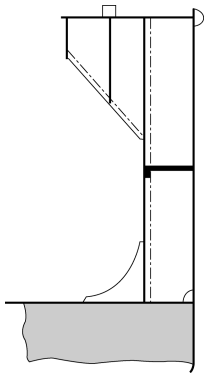


Fig 7.3.9

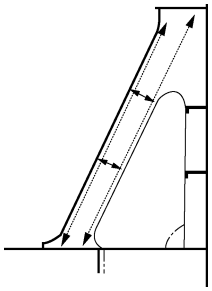


Fig 7.3.10

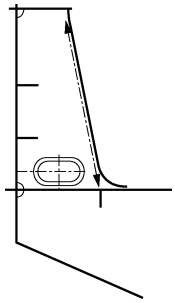


Fig 7.3.11

Section 10 Longitudinal Strength of Hull Girder in Flooded Condition for Bulk Carriers

1001. Application

1. These requirements are to be applied to non-CSR bulk carriers of 150 m in length and upwards which are contracted for construction on or after 1 July 2006, intending to carry solid bulk cargoes having a density of 1.0 t/m^3 or above, and with single side skin construction, or double side skin construction 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 centreline at the assigned summer load line.

Such ships are to have their hull girder strength checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in **Pt 3, Annex 3-1** of the Guidance and in every condition considered in the intact longitudinal strength calculations, including those and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered. (Refer to the **Annex 7-7**)

1002. Flooding criteria

1. To calculating the weight of ingressed water, the following assumptions are to be made.

(1) The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo is to be taken as 0.95.

(2) Appropriate permeabilities and bulk densities are to be used for any cargo carried.

(a) Iron ore : bulk density = 3.0 t/m^3, permeability = 0.3

(b) Cement : bulk density = 1.3 t/m^3, permeability = 0.3

(3) permeability for solid cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

2. For packed cargo conditions (such as steel mill products), the actual density of the cargo should be used with a permeability of zero.

1003. Flooding conditions

1. Floodable holds

Each cargo hold is to be considered individually flooded up to the equilibrium waterline. This application is to be applied to SUBC(Self-Unloading Bulk Carrier) where the unloading system maintains the watertightness during seagoing operations. In SUBCs with unloading systems that do not maintain watertightness, the longitudinal strength in the flooded conditions are to be considered using the extent to which the flooding may occur. *(2020)*

2. Loads

The still water loads in flooded conditions are to be calculated for the above cargo and ballast load-

ing conditions.
The wave loads in the flooded conditions are assumed to be equal to 80% of those given in **Pt 3, Ch 3, Sec. 2 Table 3.3.1** and **Sec. 3 301. 1.**

1004. Stress assessment

1. The actual hull girder bending stress σ_{fld} at any location is given by :

$$\sigma_{fld} = \frac{M_{sf} + 0.8M_w}{Z} \times 10^3 \quad (\mathrm{N/mm^2})$$

where,

M_{sf} = still water bending moment in the flooded conditions for the section under consideration ($\mathrm{kN\text{-}m}$).

M_w = wave bending moment as given in **Pt 3, Ch 3, Table 3.3.1.**

Z = section modulus for the corresponding location in the hull girder ($\mathrm{cm^3}$).

2. The shear strength of the side shell and the inner hull(longitudinal bulkhead) if any, at any location of the ship, is to be checked according to the requirements specified in **Pt 3, Ch 3, 301.** and **302.** in which F_s and F_w are to be replaced respectively by F_{SF} and F_{WF}, where :

F_{SF} = still water shear force (kN) in the flooded conditions for the section under construction

F_{WF} = 0.8 F_w

F_w = wave shear force (kN) as given in **Pt 3, Ch 3, 301.** for the section under construction

1005. Strength criteria

The damaged structure is assumed to remain fully effective in resisting the applied loading. Permissible stress and axial stress buckling strength are to be in accordance with **Pt 3, Ch 3, Table 3.3.1** and **Pt 3, Ch 3, 301.**

Section 11 Evaluation of Allowable Hold Loading for Bulk Carriers Considering Hold Flooding

1101. Application

1. These requirements are to be applied to non-CSR bulk carriers of 150 m in length and upwards which are contracted for construction on or after 1 July 2006, intending to carry solid bulk cargoes having a density of 1.0 $\mathrm{t/m^3}$ or above, and with single side skin construction, or double side skin construction 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 centreline at the assigned summer load line. (Refer to the **Annex 7-7**)

2. The loading in each hold is not to exceed the allowable hold loading in flooded condition, calculated as per **1104.**, using the loads given in **1102.** and the shear capacity of the double bottom given in **1103.**

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

1102. Loading model

1. General

(1) The loads to be considered as acting on the double bottom are those given by follows.
  (a) External sea pressures
  (b) Combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

(2) 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 :
  (a) Homogeneous loading condition.
  (b) Non-homogeneous loading condition.
  (c) Packed cargo conditions (such as steel mill products).

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

2. Inner bottom flooding head

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

(1) For ships less than 50,000 tonnes deadweight with Type B freeboard :
  (a) For the foremost hold : d_f = 0.95D
  (b) For the other holds : d_f = 0.85D

(2) In general
  (a) For the foremost hold : d_f = 1.0D
  (b) For the other holds : d_f = 0.9D

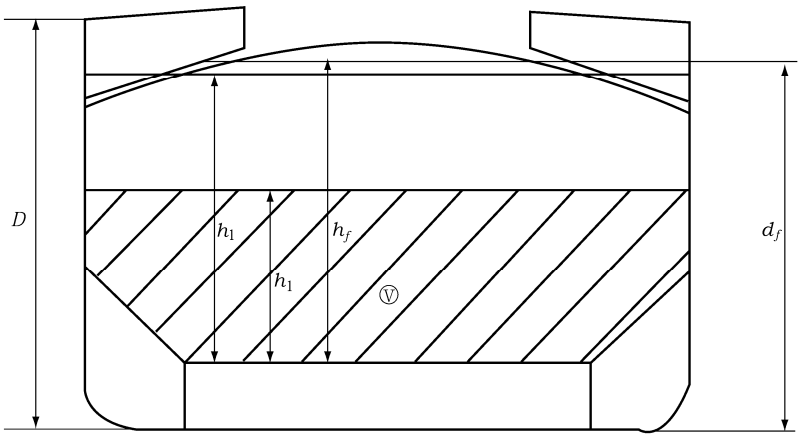


Fig. 7.3.12 Measurement of d_1, d_f, h_1 and h_f

1103. Shear capacity of the double bottom 【See Guidance】

1. The shear capacity C of the double bottom is defined as the sum of the shear strength at each end of :

(1) 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 **Fig 7.3.13**).

(2) All double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

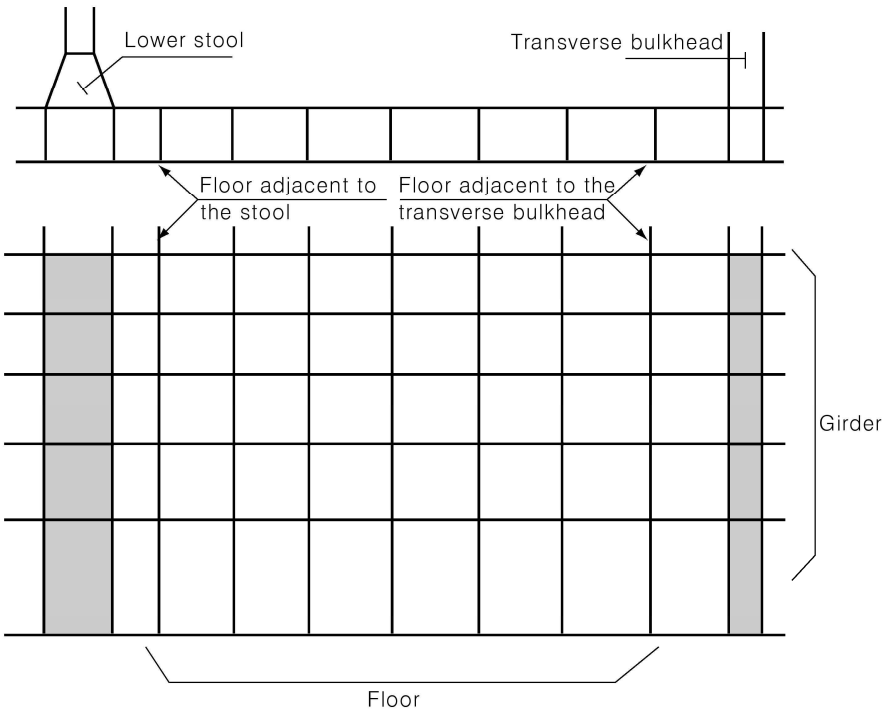


Fig 7.3.13 Floor and girder

2. Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength is to be evaluated for the one end only.

3. 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.

4. When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, the shear capacity C of double bottom is to be calculated according to the Society's discretion.

5. In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness $t_{\neq t}$ is given by :

$$t_{\neq t} = t - 2.5 \quad (\mathrm{mm})$$

t = thickness of floors and girders (mm).

6. Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} (kN) and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2} (kN), are given by :

$$S_{f1} = A_f \frac{\tau_a}{\eta_1} \times 10^{-3} \quad (\mathrm{kN})$$

$$S_{f2} = A_{f,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \quad (\mathrm{kN})$$

A_f = sectional area of the floor panel adjacent to hoppers $(\mathrm{mm^2})$.

$A_{f,h}$ = net sectional area of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) $(\mathrm{mm^2})$.

τ_a = the allowable shear stress to be taken equal to the lesser of following formulae $(\mathrm{N/mm^2})$.

$$\tau_{a1} = \frac{162\sigma_y^{0.6}}{(S/t_{\neq t})^{0.8}} \quad (\mathrm{N/mm^2}), \qquad \tau_{a2} = \frac{\sigma_y}{\sqrt{3}} \quad (\mathrm{N/mm^2})$$

For floors adjacent to the stools or transverse bulkheads, τ_a may be taken as $\sigma_y/\sqrt{3}$

σ_y = minimum upper yield stress of the material $(\mathrm{N/mm^2})$.

S = spacing of stiffening members of panel under consideration (mm).

η_1 = 1.1

η_2 = 1.2, may be reduced, to the Society's discretion, down to 1.1, where appropriate reinforcements are fitted to the Society's satisfaction.

7. Girder shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2} are given by :

$$S_{g1} = A_g \frac{\tau_a}{\eta_1} \times 10^{-3} \quad (\mathrm{kN})$$

$$S_{g2} = A_{g,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \quad (\mathrm{kN})$$

A_g = minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) $(\mathrm{mm^2})$.

$A_{g,h}$ = net sectional area of the girder panel in way of the largest opening in the outmost bay (i. e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) (mm^2).

τ_a = allowable shear stress as given in **Par 6** (N/mm^2).

η_1 = 1.1

η_2 = 1.15, may be reduced, to the Society's discretion, down to 1.1 where appropriate reinforcements are fitted to the Society's satisfaction.

1104. Allowable hold loading

The allowable hold loading W is given by :

$$W = \rho_c V \frac{1}{F} \qquad \text{(ton)}$$

F = 1.1 in general, and may be 1.05 for steel mill products.

ρ_c = Bulk cargo density (t/m^3).

V = Volume (m^3), occupied by cargo at a level h_1.

$$h_1 = \frac{X}{\rho_c g}$$

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

$$X_1 = \frac{Z + \rho g(E - h_f)}{1 + \frac{\rho}{\rho_c}(perm - 1)}$$

$$X_2 = Z + \rho g\,(E - h_f\, perm)$$

X = X_1 using $perm$ = 0, for steel products

ρ = sea water density (t/m^3).

g = gravity acceleration (= 9.81 m/s^2).

E = ship immersion (m), for flooded hold condition

= d_f - $0.1D$

d_f = as given in **1102. Par 2.**

h_f = flooding head as defined in **1102. Par 2** (m).

$perm$ = cargo permeability, defined in **1002. Par 1.** it needs not be taken greater than 0.3 and is to be taken equal to zero for steel mill products.

Z = the lesser of Z_1 and Z_2 given by :

$$Z_1 = \frac{C_h}{A_{DB,h}}$$

$$Z_2 = \frac{C_e}{A_{DB,e}}$$

C_h = shear capacity of the double bottom, as defined in **1103.** considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (See **1103. Par 6**) and for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (See **1103. Par 7**) (kN).

C_e = shear capacity of the double bottom as defined in **1103.** considering, for each floor, the shear strength S_{f1} (See **1103. Par 6**) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (See **1103. Par 7**) (kN).

$$A_{DB,h} = \sum_{i=1}^{n} S_i B_{DB,i}$$

$$A_{DB,e} = \sum_{i=1}^{n} S_i (B_{DB} - S_l)$$

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

S_i = spacing of i th-floor (m).

$B_{DB,i}$ = $B_{DB} - S_l$, for floors whose shear strength is given by S_{f1}.

= $B_{DB,h}$, for floors whose shear strength is given by S_{f2}

B_{DB} = breadth of double bottom between hoppers (m) (See Fig **7.3.14**).

$B_{DB,h}$ = distance between the two considered opening (m) (See Fig **7.3.14**).

S_l = spacing of double bottom longitudinals adjacent to hoppers (m).

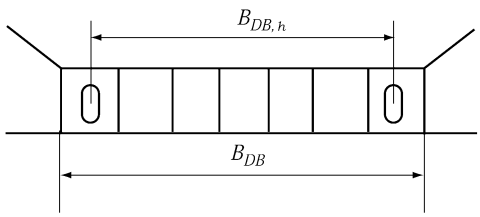


Fig. 7.3.14 Measurement $B_{DB,h}$ and B_{DB}

Section 12 Evaluation of Scantlings of Corrugated Transverse Watertight Bulkheads in Bulk Carriers Considering Hold Flooding

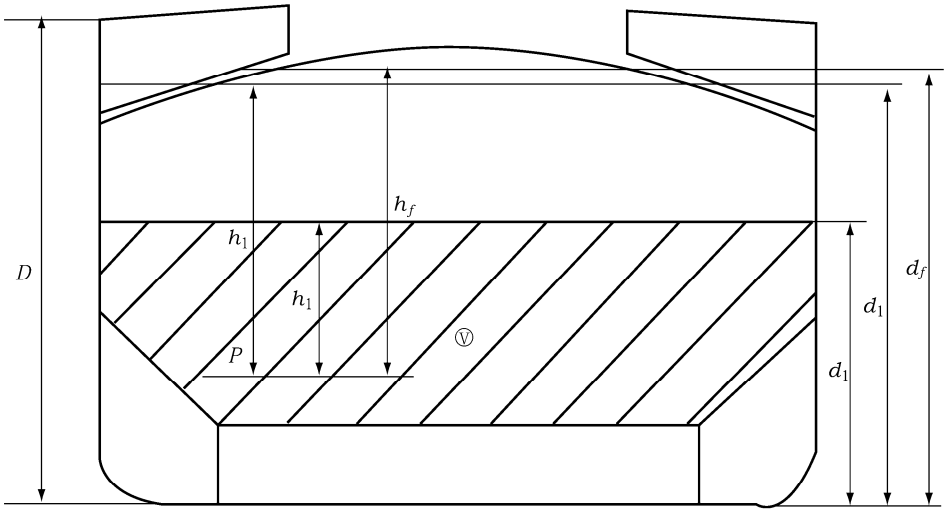
1201. Application and definitions

1. These requirements are to be applied to non-CSR bulk carriers of 150 m in length and upwards which are contracted for construction on or after 1 July 2006, intending to carry solid bulk cargoes having a density of 1.0 t/m^3 or above, and with single side skin construction, or double side skin construction 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 centreline at the assigned summer load line. (Refer to the **Annex 7-7**)

2. The net thickness t_{net} is the thickness obtained by applying the strength criteria given in **1204.**

3. The required thickness is obtained by adding the corrosion addition t_s, given in **1206.** to the net thickness t_{net}.

4. In this requirement homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1.2 to be corrected for different cargo densities (See, Fig **7.3.15**).



V : Volume of cargo
P : Calculation point

Fig 7.3.15 Measurement of d_1, d_f, h_1 and h_f

1202. Load model

1. General

(1) The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone is to be considered. This application is to be applied to SUBC(Self-Unloading Bulk Carrier) where the unloading system maintains the watertightness during seagoing operations. In SUBCs with unloading systems that do not maintain watertightness, the combination loads acting on the bulkheads in the flooded conditions are to be considered using the extent to which the flooding may occur. *(2020)*

(2) The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual :
  (a) homogeneous loading conditions;
  (b) non-homogeneous loading conditions(considering the individual flooding of both loaded and empty holds);

(3) The specified design load limits for the cargo holds are to be represented by loading conditions defined by the Designer in the loading manual.

(4) 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.

(5) Holds carrying packed cargoes are to be considered as empty holds for this application.

(6) Unless the ship is intended to carry, in non homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78 $\mathrm{t/m^3}$, the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold volume up to the upper deck level at centreline.

2. Bulkhead corrugation flooding head

The flooding head h_f (See Fig **7.3.15**) is the distance (m) measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f (m) from the baseline equal to :

(1) For ships less than 50,000 tonnes deadweight with Type B freeboard
  (a) for the foremost transverse corrugated bulkhead : d_f = 0.95D
  (b) for the other bulkheads : d_f = 0.85D

(2) For ships less than 50,000 tonnes deadweight with Type B freeboard and the ship is to carry cargoes having bulk density less than I.78 t/m^3 in non-homogeneous loading conditions.
(a) for the foremost transverse corrugated bulkhead : d_f = 0.9D
(b) for the other bulkheads : d_f = 0.8D

(3) In general
(a) for the foremost transverse corrugated bulkhead : d_f = D
(b) for the other bulkheads : d_f = 0.9D

(4) In (3), where the ship is to carry cargoes having bulk density less than 1.78 t/m^3 in non-homogeneous loading conditions.
(a) for the foremost transverse corrugated bulkhead : d_f = 0.95D
(b) for the other bulkheads : d_f = 0.85D

3. Pressure in the non-flooded bulk cargo loaded holds

(1) At each point of the bulkhead, the pressure P_c is given by :

$$P_c = \rho_c g h_1 \tan^2\gamma \quad (kN/m^2)$$

ρ_c = bulk cargo density (t/m^3).
g = gravity acceleration (= 9.81 m/s^2).
h_1 = vertical distance (m), from the calculation point to horizontal plane corresponding to the level height of the cargo (See **Fig 7.3.15**), located at a distance d_1 (m) from the baseline.
γ = 45° - (ϕ / 2)
ϕ = angle of repose of the cargo, that may generally be taken as 35° for iron ore and 25° for cement.

(2) The force F_c acting on a corrugation is given by :

$$F_c = \rho_c g S_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \tan^2\gamma \quad (kN)$$

ρ_c, d_1, g and γ = as given above (1).
S_1 = spacing of corrugations (m) (See **Fig 7.3.16**).
h_{LS} = mean height of the lower stool from the inner bottom (m).
h_{DB} = height of the double bottom (m).

4. Pressure in the flooded holds

(1) Bulk cargo holds
Two cases are to be considered, depending on the values of d_1 and d_f.
(a) $d_f \geq d_1$
(i) At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure P_{cf} is given :

$$P_{cf} = \rho g h_f \quad (kN/m^2)$$

ρ = sea water density (t/m^3).
g = as defined in **1202. Par 3.** (1).
h_f = flooding head as defined in **1202. Par 2.**

(ii) At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure P_{cf} is given by :

$$P_{cf} = \rho g h_f + [\rho_c - \rho(1 - perm)]\, g h_1 \tan^2\gamma \quad (kN/m^2)$$

ρ and h_f = as defined in above (i).

ρ_c, g, h_1 and γ = as defined in **1202. Par 3.**

$perm$ = permeability of cargo, as defined in **1202. Par 1.**

(iii) The force F_{cf} acting on a corrugation is given by :

$$F_{cf} = S_1 \left[\frac{\rho g (d_f - d_1)^2}{2} + \frac{\rho g (d_f - d_1) + (P_{cf})_{le}}{2} (d_1 - h_{DB} - h_{LS}) \right] \quad (\mathrm{kN})$$

where,

ρ = as defined in (i).

S_1, g, d_1, h_{LS} and h_{DB} = as given in **Par 3.**

d_f = as given in **Par 2.**

$(P_{cf})_{le}$ = pressure at the lower end of the corrugation ($\mathrm{kN/m^2}$).

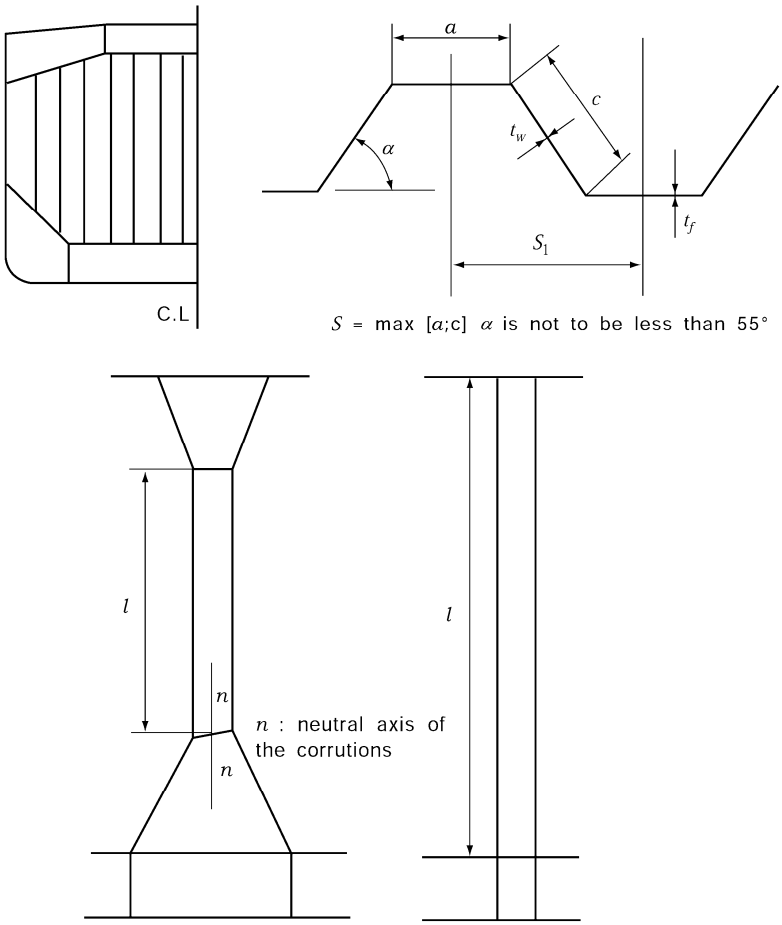


Fig 7.3.16 Measurement of S and l

(b) $d_f < d_1$

(i) At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure P_{cf} is given by :

$$P_{cf} = \rho_c g h_1 \tan^2\gamma \quad (\mathrm{kN/m^2})$$

ρ_c, g, h_1 and γ = as given in above **Par 3.**

(ii) At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure, P_{cf}, is given by :

$$P_{cf} = \rho g h_f + [\rho_c h_1 - \rho(1-perm) h_f] g \tan^2\gamma \quad (\mathrm{kN/m^2})$$

where,

ρ, h_f and $perm$ = as given in above (a).

ρ_c, g, h_1 and γ = as given in above **Par 3.**

(iii) The force, F_{cf}, acting on a corrugation is given by :

$$F_{cf} = S_1 \left[\frac{\rho_c g (d_1 - d_f)^2}{2} \tan^2\gamma + \frac{\rho_c g (d_1 - d_f) \tan^2\gamma + (P_{cf})_{le}}{2} (d_f - h_{DB} - h_{LS}) \right] \quad (\mathrm{kN})$$

where,

ρ_c, S_1, g, d_1, γ, h_{DB} and h_{LS} = as given by above **Par 3.**

d_f = as given by above **Par 2.**

$(P_{cf})_{le}$ = pressure, at the lower end of the corrugation $(\mathrm{kN/m^2})$

(2) Pressure in empty holds due to flooding water alone

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, acting on a corrugation is given by :

$$F_f = S_1 \rho g \frac{(d_f - h_{DB} - h_{LS})^2}{2} \quad (\mathrm{kN})$$

where,

ρ = as given by (1), (a), (i).

S_1, g, h_{DB} and h_{LS} = as given by **Par 3.**

d_f = as given by **Par 2.**

5. Resultant pressure and force

(1) Homogeneous loading conditions

(a) At each point of the bulkhead structures, the resultant pressure, P, to be considered for the scantlings of the bulkhead is given by ;

$$P = P_{cf} - 0.8 P_c \quad (\mathrm{kN/m^2})$$

(b) The resultant force F, acting on a corrugation is given by ;

$$F = F_{cf} - 0.8 F_c \quad (\mathrm{kN})$$

(2) Non-homogeneous loading conditions

(a) At each point of the bulkhead structures, the resultant pressure P, to be considered for the scantlings of the bulkhead is given by :

$$P = P_{cf} \quad (\mathrm{kN/m^2})$$

(b) The resultant force F, acting on a corrugation is given by :

$$F = F_{cf} \quad (kN)$$

1203. Bending moment and shear force in the bulkhead corrugations

The bending moment M and the shear force Q in the bulkhead corrugations are given by:

1. Bending moment

$$M = \frac{Fl}{8} \quad (\text{kN-m})$$

F = resultant force, as given in **1202. Par 5.** (kN).

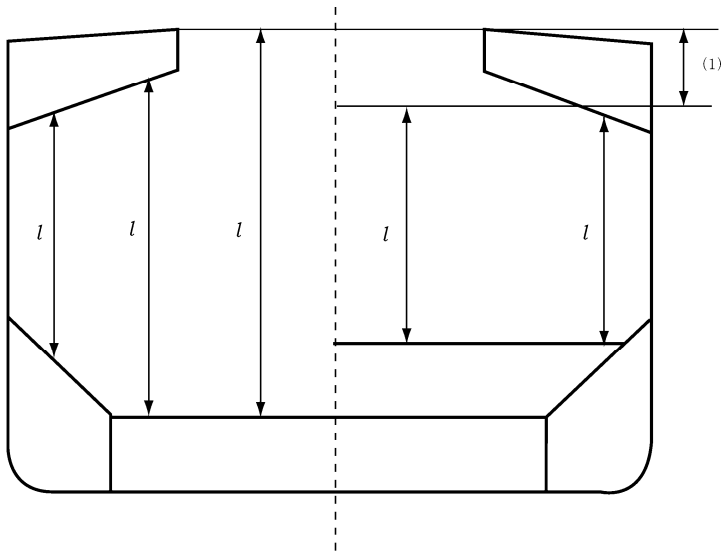
l = span of the corrugation (m) (See, **Fig 7.3.16** and **Fig 7.3.17**).

2. Shear force

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

$$Q = 0.8F \quad (\text{kN})$$

F = as given in above **Par 1.**



(Note) (1) For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centerline equal to:
(1) For rectangular stool : 2 times the depth of corrugations.
(2) In general : 3 times the depth of corrugations.

Fig 7.3.17 Measurement of span l

1204. Strength criteria

1. General

The following criteria are applicable to transverse bulkheads with vertical corrugations (See **Fig 7.3.16**).

(1) For ships of 190 m of length and above, these bulkheads are to be fitted with a bottom stool, and generally with a top stool below deck. For smaller ships, corrugations may extend from inner bottom to deck.
(2) The corrugation angle(α) shown in Fig **7.3.16** is not to be less than 55°.
(3) Requirements for local net plate thickness, t_{net} are given in **Par 7.** In addition, the criteria given in **Par 2** and **5** are to be complied with.

(4) The thicknesses of the lower part of corrugations considered in the application of **Par 2** and **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 $0.15\,l$.

(5) The thicknesses of the middle part of corrugations as considered in the application of **Par 2** and **4** are to be maintained to a distance from the deck or the bottom of the upper stool not greater than $0.3\,l$.

(6) The section modulus of the corrugation in the remaining upper part of the bulkhead is not to be less than 75 % of that required for the middle part, corrected for different yield stresses.

(7) Lower stool

(A) The height of the lower stool is generally to be not less than 3 times the depth of the corrugations. The thickness and material of the stool top plate is not to be less than those required for the bulkhead plating above.

(B) The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top is not to be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation.

(C) The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than the value given by the following formulae.

(a) The thickness of the stool side plating

(i) $d_f \geq d_1$

$$t = CS\sqrt{h_1' K} + 2.5 \quad (\mathrm{mm})$$

(ii) $d_f < d_1$

$$t = CS\sqrt{h_2' K} + 2.5 \quad (\mathrm{mm})$$

where,

C = coefficient given by the following formula.

$C = 3.825 C_1$

C_1 = coefficient given by the following formula according to the value l/S.

$$1 \leq \frac{l}{S} < 3.5 \quad : \left(0.11\frac{l}{S} + 0.615\right)$$

$$3.5 \leq \frac{l}{S} \quad : 1.0$$

S = length of the shorter side of the panel enclosed by stiffeners, etc.

l = length of the longer side of the panel enclosed by stiffeners, etc.

h_1' and h_2' = as given in following formulae.

$$h_1' = h_f + \left\{\frac{\rho_c}{\rho} - (1 - perm)\right\} h_1(\sin^2\beta\tan^2\gamma + \cos^2\beta)$$

$$h_2' = h_f + \left\{\frac{\rho_c}{\rho} h_1 - (1 - perm) h_f\right\} (\sin^2\beta\tan^2\gamma + \cos^2\beta)$$

β = slope angle of stool side plate (deg).

h_f = as given in **1202. Par 2.**

ρ_c, h_1 and γ = as given in **1202. Par 3.**

ρ = as given in **1202. Par 4.**

$perm$ = permeability of cargo, as defined in **1002. Par 1,** (3).

(b) The section modulus of the stool side vertical stiffeners

(i) $d_f \geq d_1$

$$Z = 7.8KSh_1'l^2 \quad (\mathrm{cm}^3)$$

(ii) $d_f < d_1$

$$Z = 7.8KSh_2'l^2 \quad (\mathrm{cm}^3)$$

where,

S = spacing of stiffeners (m).

l = unsupported length of stiffener (m).

h_1' and h_2' = as given in (a).

(D) The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Fig **7.3.18.**

(E) The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2.5 times the mean depth of the corrugation. The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

(F) Where corrugations are cut at the bottom stool, corrugated bulkhead plating is to be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds.(See Fig **7.3.20**) The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration welds.(See Fig **7.3.20**)

(G) The plating of the lower stool and supporting floors is generally to be connected to the inner bottom by full penetration welds.

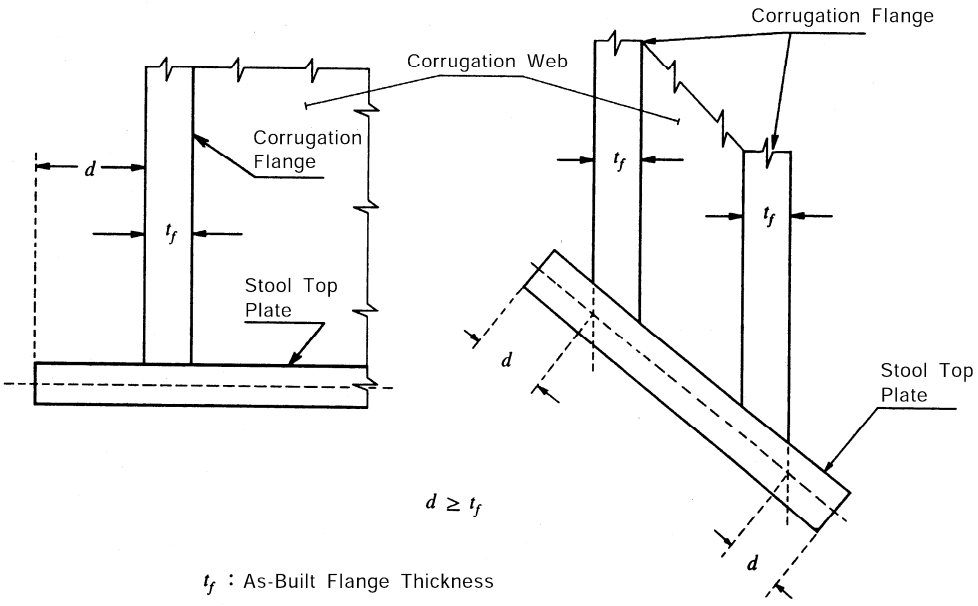


Fig 7.3.18 Permitted distance, d, from edge of stool top plate to surface of corrugation flange

(8) Upper stool

(A) The upper stool, where fitted, is to have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools are to have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder.

(B) The upper stool is to be properly supported by girders or deep brackets between the ad-

jacent hatch-end beams.

(C) The width of the stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non rectangular stools is to have a width not less then 2 times the depth of corrugations. The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below.

(D) The thickness of the lower portion of stool side plating is not to be less than 80 % of that required for the upper part of the bulkhead plating where the same material is used.

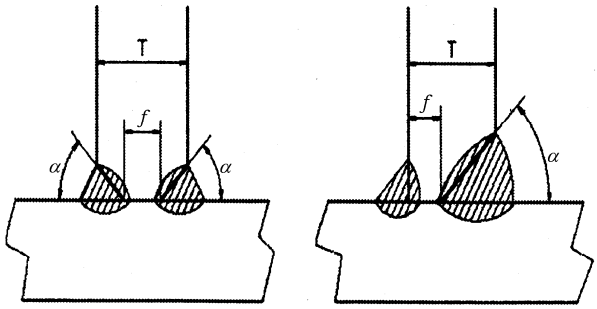
(E) The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by the Society on the basis of the load model in (7), (C). The ends of stool side stiffener are to be attached to brackets at upper and lower end of the stool.

(F) Diaphragms are to be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

(9) Alignment

(A) At deck, if no stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

(B) At bottom, if no stool is fitted, the corrugation flanges are to be in line with the supporting floors. Corrugated bulkhead plating is to be connected to the inner bottom plating by full penetration welds. The plating of supporting floors is to be connected to the inner bottom by either full penetration or deep penetration welds. (See **Fig 7.3.20**)



Root face (f) : $3mm \sim T/3mm$
Groove Angle (α) : $40° \sim 60°$

Fig 7.3.20 Welding methods

(C) The thickness and material properties of the supporting floors are to be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinal to double bottom floors are to be closed by collar plates.

(D) The supporting floors are to be connected to each other by suitably designed shear plates, as deemed appropriate by the Society.

(E) Stool side plating is to align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating is not to be knuckled anywhere between the inner bottom plating and the stool top.

2. Bending capacity and shear stress

(1) The bending capacity is to be comply with the following relationship :

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

M = bending moment, as given in **1203. Par 1** (kN-m).

Z_{le} = section modulus of one half pitch corrugation, at the lower end of corrugations, as given in **Par 3** (cm^3).

Z_m = section modulus of one half pitch corrugation, at the mid-span of corrugations, as given in **Par 4** (cm^3).

$\sigma_{a,le}$ = allowable stress, as given in **Par 5,** for the lower end of corrugations ($\mathrm{N/mm}^2$).

$\sigma_{a,m}$ = allowable stress, as given in **Par 5,** for the mid-span of corrugations ($\mathrm{N/mm}^2$).

(A) In no case Z_m is to be taken greater than the lesser of 1.15 Z_{le} and 1.15 Z'_{le} for calculation of the bending capacity, Z'_{le} being defined below.

(a) In case shedder plates are fitted which :

- are not knuckled;
- are welded to the corrugations and the top of the lower stool by one side penetration weld or equivalent;
- are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating;
- have thicknesses not less than 75 % of that provided by the corrugation flange ;
- and material properties at least equal to those provided by the flanges.

(b) Or gusset plates are fitted which:

- are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements;
- have a height not less than half of the flange width;
- are fitted in line with the stool side plating;
- are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent.
- have thickness and material properties at least equal to those provided for the flanges.

(B) The section modulus Z_{le}, is to be taken not larger than the value Z'_{le}, given by :

$$Z'_{le} = Z_g + \frac{Qh_g - 0.5h_g^2 S_1 P_g}{\sigma_a} \times 10^3 \quad (\mathrm{cm}^3)$$

Z_g = section modulus of one half pitch corrugation calculated, according to **Par 4.** in way of the upper end of shedder or gusset plates, as applicable (cm^3).

Q = shear force, as given in **1203. Par 2.** (kN).

h_g = height of shedder or gusset plates (m), as applicable (See Fig **7.3.19** (1), (2), (3) and (4)).

S_1 = as given in **1202. Par 3.**

P_g = resultant pressure, as defined in **1202. Par 5.** calculated in way of the middle of the shedder or gusset plates ($\mathrm{kN/m}^2$), as applicable.

σ_a = allowable stress, as given in **Par 5.** ($\mathrm{kN/m}^2$).

(2) Shear stress τ is 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 ($\sin\alpha$), α being the angle between the web and the flange.

(3) When calculating the section modulus and the shear area, the t_{net} plate thicknesses are to be used.

(4) The section modulus of corrugations are to be calculated on the basis of the following requirements given in **Par 3** and **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, b_{ef}, not larger than as given in **Par 6.** 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.

(1) Provided that effective shedder plates, as defined in above **Par 2** are fitted (See Fig **7.3.19** (1) and (2)), when calculating the section modulus of corrugations at the lower end (cross-section ① in Fig **7.3.19** (1) and (2)), the area of flange plates may be increased by $2.5a\sqrt{t_f t_{sh}}$ (not to be taken greater than $2.5\,at_f$).

a = width of the corrugation flange (m) (See Fig **7.3.12**).

t_{sh} = net shedder plate thickness (mm).

t_f = net flange thickness (mm).

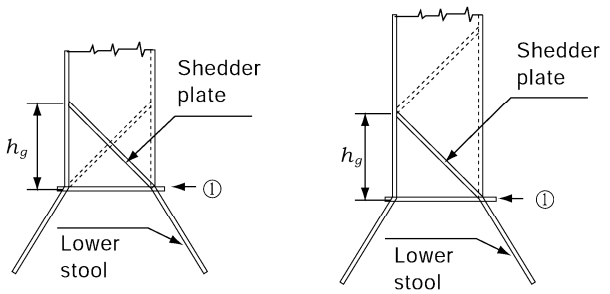
(2) Provided that effective gusset plates, as defined in above **Par 2** are fitted (See Fig **7.3.19** (3) and (4)), when calculating the section modulus of corrugations at the lower end (cross-section ① in Fig **7.3.19** (3) and (4)), the area of flange plates may be increased by $7\,h_g t_f$.

h_g = height of gusset plate (m), see Fig **7.3.19** (3) and (4), not to be taken greater than $\frac{10}{7}S_{gu}$

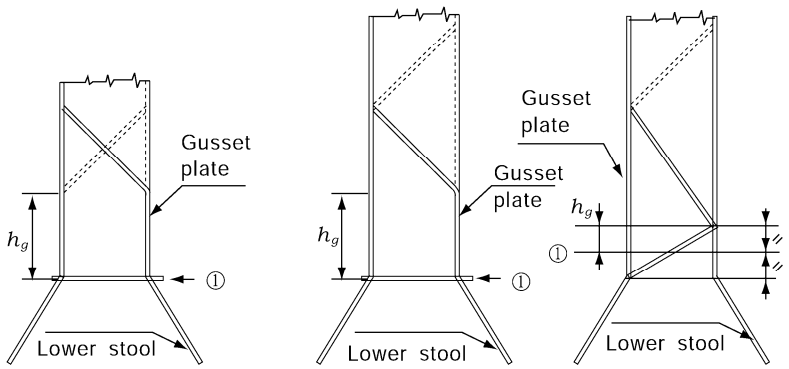
S_{gu} = width of the gusset plates (m).

t_f = net flange thickness based on the as built condition (mm).

(3) If the corrugation webs are welded to a sloping stool top plate, which have an angle not less than 45° 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 above (2). No credit can be given to shedder plates only. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30 % for 0° and 100 % for 45°.



(1) Symmetric shedder plates (2) Asymmetric shedder plates



(3) Symmetric gusset/shedder plates (4) Asymmetric gusset/shedder plates

Fig. 7.3.19 Shedder plate and gusset plate

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 **Par 6.**

5. Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a given by:

$$\sigma_a = \sigma_y \quad (\mathrm{N/mm^2})$$
$$\tau_a = 0.5\sigma_y \quad (\mathrm{N/mm^2})$$

σ_y = the minimum upper yield stress of the material $(\mathrm{N/mm^2})$.

6. Effective compression flange width and shear buckling checks

(1) Effective width of the compression flange of corrugations
The effective width b_{ef} of the corrugation flange is given by :

$$b_{ef} = C_e\,\alpha \quad (\mathrm{m})$$
$$\beta > 1.25 \ : \ C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2}$$
$$\beta \le 1.25 \ : \ C_e = 1.0$$
$$\beta = \frac{a}{t_f}\sqrt{\frac{\sigma_y}{E}} \times 10^3$$

where,
t_f = net flange thickness (mm).
α = width of the corrugation flange (m) (See **Fig 7.3.16**)
σ_y = the minimum upper yield stress of the material $(\mathrm{N/mm^2})$.
E = modulus of elasticity of the material $(\mathrm{N/mm^2})$ to be assumed equal to 2.06×10^5 for steel.

(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 , as given by the following formulae.

$$\tau_c = \tau_E \qquad : \quad \tau_E \le 0.5\tau_y$$

$$\tau_c = \tau_y\left(1 - \frac{\tau_y}{4\tau_E}\right) \qquad : \quad \tau_E > 0.5\tau_y$$

where,
τ_y = shear stress of material $(\mathrm{N/mm^2})$, t_y is to be determined as $\sigma_y/\sqrt{3}$
τ_E = ideal elastic buckling stress is determined as following :

$$\tau_E = 0.9\,k_t E\left(\frac{t}{1000\,c}\right)^2 \quad (\mathrm{N/mm^2})$$

$k_t = 6.34$
t = net thickness of corrugation web (mm).
c = width of corrugation web (m). (See, **Fig 7.3.16**)
σ_y and E = as given in above (1).

7. Local net plate thickness

(1) The bulkhead local net plate thickness t_{net} is given by :

$$t_{net} = 14.9 S_w \sqrt{\frac{1.05P}{\sigma_y}} \quad (\mathrm{mm})$$

where,

S_w = plate width, to be taken equal to the width of the corrugation flange or web, whichever is the greater (m) (See Fig **7.3.16**).

P = resultant pressure as defined in **1202. Par 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 sheddres, if shedders or gusset/shedder plates are fitted ($\mathrm{kN/m^2}$).

σ_y = minimum upper yield stress of the material ($\mathrm{kN/m^2}$).

(2) For built-up corrugation bulkheads, when the thicknesses of the flange and web are different,

(A) The net thickness of the narrower plating is to be not less than t_n, given by :

$$t_n = 14.9 S_n \sqrt{\frac{1.05P}{\sigma_y}} \quad (\mathrm{mm})$$

where,

S_n = the width of the narrow plating (m).

P and σ_y = as given in (1).

(B) The net thickness of the wider plating is not to be taken less than the maximum of the following values :

$$t_{w1} = 14.9 S_w \sqrt{\frac{1.05P}{\sigma_y}} \quad (\mathrm{mm})$$

$$t_{w2} = \sqrt{\frac{440\, S_w^2 \times 1.05\, P}{\sigma_y} - t_{np}^2} \quad (\mathrm{mm})$$

where,

t_{np} = not to be more than the smaller value of the actual net thickness of the narrower plating and t_{w1}.

S_w = the breath of the wider plating (m).

P and σ_y = as given in (1).

1205. Local details

1. As applicable, the design of local details is to be designed such that transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures, is sufficient.

2. In particular, the thickness and stiffening of effective gusset and shedder plates is to comply with the Society requirement, on the basis of the load model in **1204. Par 2.**

1206. Corrosion addition

The corrosion addition t_s is to be taken equal to 3.5 mm.

Section 13 Requirements for the Fitting of a Forecastle for Bulk Carriers, Ore Carriers and Combination Carriers

1301. Application and definitions

These requirements apply to all bulk carriers, ore carriers and combination carriers which are contracted for construction on or after 1 January 2004. Such ships are to be fitted with an enclosed forecastle on the freeboard deck. The required dimensions of the forecastle are defined in **1302.**
The structural arrangements and scantlings of the forecastle are to be determined at the discretion of the Society.

1302. Dimensions

1. The forecastle is to be located on the freeboard deck with its an bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in **Fig 7.3.21.**

However, if this requirements hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7% of the ship length abaft the forward perpendicular where the ship length and forward perpendicular are defined in the International Convention of Load Line 1966 and its Protocol 1988.

2. The forecastle height H_F above the main deck is to be not less than:

- the standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988,
- $H_C + 0.5\,\mathrm{m}$, where is the height of the forward transverse hatch coaming of cargo hold No.1, whichever is the greater.

3. All points of the aft edge of the forecastle deck are to be located at a distance l_F:
$l_F \leq 5\sqrt{H_F - H_C}$ from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover in applying **Sec. 9. 904. 1.** and **905. 2.**

4. A breakwater is not to be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centre line is not less than $H_B/\tan 20^\circ$ forward of the aft edge of the forecastle deck, where h_B is the height of the breakwater above the forecastle (see **Fig 7.3.21**).

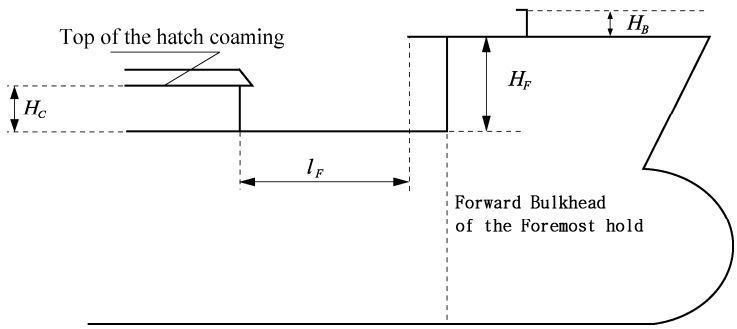


Fig 7.3.21

Section 14 Water Level Detection & Alarms and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships

1401. General【See Guidance】

Arrangements, testing and etc. for water level detectors, alarms and drainage, pumping systems required by **1403.** and **1404.** are to be followed in accordance with the requirements of the **Annex 7-6 「Water Level Detection & Alarms and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships」.** *(2021)*

1402. Application

The requirements of this section apply to the ships of 500 tons gross tonnage and above and engaged on international voyage as follows;

1. A ship which is constructed before 1 July 2006 and constructed generally with single deck, top-side tanks and hopper side tanks in cargo spacs, and is intended primarily to carry dry cargo in bulk, and includes such types as ore carriers and combination carriers and a ship which is constructed on or after 1 July 2006 and is intended primarily to carry dry cargo in bulk, and includes such types as ore carriers and combination carriers(hereinafter referred to as 「Bulk carrier」) are to be installed relevant systems in accordance with the requirements in **1403. 1** and **1404.**

2. Cargo ships other than bulk carriers having a single cargo hold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to the deck(hereinafter referred to as「Single hold cargo ship」) and come fall under following (1) or (2) are to be installed relevant systems in accordance with the requirements of **1403. 3.**

(1) Ships having a length(L) of less than 80 m if constructed on or after 1 July 1998
(2) Ships having a length(L) of less than 100 m if constructed before 1 July 1998

However, the water level detectors required by **1403. 3** need not be fitted in ships fitted with water level detectors complying with the requirements in **1403. 1**, or in ships having suitable width watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck. **【See Guidance】**

Ships constructed before 1 January 2007 are to be in accordance with the requirements in **Pt 1, Ch.2, 1802.**

1403. Water level detectors, alarms and etc.

1. Water level detectors, audible and visual alarms are to be fitted in each cargo hold, ballast tanks forward of the collision bulkhead, dry space and void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold for bulk carriers.

2. Such alarms specified in **Par. 1** need not be provided in enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume.

3. Single hold cargo ships having a length(L) of less than 80 m(ships having a length(L) of less than 100 m if constructed before 1 July 1998) are to be fitted with water level detectors, audible and visual alarms in cargo hold. And ships having cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to the deck are to be fitted with water level detectors, audible and visual alarms in each cargo hold.

4. The audible and visual alarms specified in **Par. 1** and **3** shall be located on the navigation bridge.

1404. Draining and pumping system

1. Means for draining and pumping ballast tanks forward of the collision bulkhead and bilges of dry spaces other than chain lockers, in any part of which extends forward of the foremost cargo hold and the volume of which exceeds 0.1% of the ship's maximum displacement volume are to be provided.

2. Means for draining and pumping specified in **Par. 1** brought into operation from a readily accessible enclosed space, the location of which is accessible from the navigation bridge or propulsion machinery control position without traversing exposed freeboard or superstructure decks.

Section 15 Supplementary Provisions for Carriage of Liquid in Holds

1501. General 【See Guidance】

1. Bulk carriers whose holds are loaded with cargo oil (hereinafter referred to as "B/O Carriers") are to be in accordance with the requirements in this Section and also those for oil tankers.
2. Other important items required for B/O carriers than those specified in this Section are to be at the discretion of the Society.
3. Where holds are loaded with cargo oil or ballast water, the scantlings of plates, stiffeners and girders composing bilge hopper tanks, topside tanks, transverse bulkheads and their stools as well as side structures are not to be less than those obtained from the relevant formulae, where the value of h specified in **Pt 3, Ch 15, 105.** is applied. The scantlings of structural members of double bottom under holds loaded with ballast are to be at the discretion of the Society.
4. When ships are designed to transport alternatively oil having a flash point below 60°C (closed cup test) or dry cargoes, openings which may be used for cargo operations are not permitted in bulkheads and decks separating oil cargo spaces from other spaces not designed and equipped for the carriage of oil cargoes unless alternative approved means are provided to ensure equivalent integrity.

1502. Holds half-loaded with cargo oils 【See Guidance】

Where holds are half-loaded with cargo oils, special care is to be taken to avoid synchronization of the natural period of oscillation of liquid in the holds with the natural periods of rolling and pitching of the ship. Where synchronization is not avoidable, plating, stiffeners and girders of transverse bulkheads and topside tanks are to be specially strengthened.

Section 16 Electrical Equipment of Coal Carriers

1601. General

The requirements in this Section apply to the electrical equipment installed in the cargo holds and the compartments adjacent thereto of coal carriers.

1602. Dangerous spaces

The following spaces and zones are dangerous spaces, therefore no electrical equipment except those of explosion protected type is to be installed
(1) Enclosed cargo holds
(2) Ventilation ducts for cargo holds

1603. Electrical equipment 【See Guidance】

1. Electrical equipment in cargo hold

In principle no electrical equipment is to be installed in the cargo holds. Where it is inevitable to install electrical equipment in the holds, the equipment is to comply with the following requirements:

(1) Switches and socket-outlets are not to be installed except those connected to intrinsically safe circuits.
(2) In case where other electrical equipment than those specified in (1) above is inevitably installed, the equipment and its associated cables are to be installed so as to be kept from mechanical damage. In addition, the feeder circuits for the equipment are to be provided with multipole linked isolating switches situated outside the holds, so deviced as to have the equipment usually locked with the switch in "off" position.
(3) The cables passing through the cargo holds are to be led in gastight heavy gauge steel pipes, and the both ends of the pipes are to be sealed using cable glands and the like in way of the boundaries of the cargo holds.

2. Electrical equipment in the compartments adjacent to cargo holds

The electrical equipment which is installed in the compartments adjacent to the cargo holds and having an opening such as non-gastight door, hatch and like in their bulkheads and decks is to be of explosion protected type accepted by the Society.

3. Cargo lamps

Cargo lamps to be led and used in the cargo holds are to be the types accepted by the Society.

Section 17 Renewal Criteria for Side Shell Frames and Brackets in Single Side Skin Bulk Carriers and Single Side Skin OBO Carriers

1701. Application and definitions

1. These requirements apply to the side shell frames and brackets of cargo holds bounded by the single side shell of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which were not built in accordance with **Ch 3, Sec. 7.**
2. In addition, these requirements also apply to the side shell frames and brackets of cargo holds bounded by the single side shell of Oil/Bulk/Ore(OBO) carriers, as defined in **Pt 1, Annex 1-1** of the Guidance relating to the Rules but of single side skin construction.
3. In the case a vessel as defined above does not satisfy above definition in one or more holds, the requirements in this section do not apply to these individual holds.
4. For the purpose of this section, "ships" means both "bulk carriers" and "OBO carriers" as defined above, unless otherwise specified.
5. Bulk carriers subject to these requirements are to be assessed for compliance with the requirements of this rules, the details of these requirements to be followed **Pt 1, Ch 3, 201.** (4) (A).
6. OBO carriers subject to these requirements are to be assessed for compliance with the requirements of this rules, the details of these requirements to be followed **Pt 1, Ch 3, 201.** (4) (B).
7. These requirements define steel renewal criteria or other measures to be taken for the webs and flanges of side shell frames and brackets as per **1702.**
8. Reinforcing measures of side frames are also defined as per **1702. 3.**
9. Finite element or other numerical analysis or direct calculation procedures cannot be used as an alternative to compliance with the requirement of this rule, except in cases off unusual side structure arrangements or framing to which the requirements of this rule cannot be directly applied. **【See Guidance】**
10. Ice strengthened ships
    (1) Where ships are reinforced to comply with an ice class notation the intermediate frames are not to be included when considering compliance with this rule
    (2) The renewal thicknesses for the additional structure required to meet the ice strengthening notation are to be based on **Pt 3, Ch 20.**
    (3) If the ice class notation is requested to be withdrawn, the additional ice strengthening structure, with the exception of tripping brackets (see **1702. 1** (2) (A) (b) and **1702. 3**), is not considered to contribute to compliance with this requirement.

1702. Renewal or other measures 【See Guidance】

1. Criteria for renewal or other measures
   (1) Symbols

t_M = thickness as measured (mm)

t_{REN} = thickness at which renewal is required. See **1702. 1** (2)

$t_{REN,d/t}$ = thickness criteria based on d/t ratio. See **1702. 1** (2) (A)
$t_{REN,S}$ = thickness criteria based on strength. See **1702. 1** (2) (B)
t_{COAT} = $0.75\,t_{S12}$
t_{S12} = thickness (mm) as required by **106. 3, 4** for frame webs and by **702.** for upper and lower brackets webs
t_{AB} = thickness as built (mm)
t_C = See **Table 7.3.12** below

Table 7.3.12 t_C Values (mm)

Ship's length L, (m)	Hold other than No.1		Hold No.1	
	Span and upper brackets	Lower brackets	Span and upper brackets	Lower brackets
≤100	2.0	2.5	2.0	3.0
150	2.0	3.0	3.0	3.5
≥200	2.0	3.0	3.0	4.0
Note: For intermediate ship lengths, t_C is obtained by linear interpolation between the above values.				

(2) Criteria for webs (Shear and other checks)
The webs of side shell frames and brackets are to be renewed when the measured thickness (t_M) is equal to or less than the thickness (t_{REN}) as defined below:

t_{REN} is the greatest of:

(a) $t_{COAT} - t_C$
(b) $0.75\,t_{AB}$
(c) $t_{REN,d/t}$ (applicable to Zone A and B only)
(d) $t_{REN,S}$ (where required by **1702. 1** (2) (B))

(A) Thickness criteria based on d/t ratio
Subject to (b) and (c) below, $t_{REN,d/t}$ is given by the following equation:

$$t_{REN,d/t} = (\text{web depth (mm)}) / R$$

where:
R = for frames
$65\sqrt{K}$ for symmetrically flanged frames
$55\sqrt{K}$ for asymmetrically flanged frames
for lower brackets (see (a) below):
$87\sqrt{K}$ for symmetrically flanged frames
$73\sqrt{K}$ for asymmetrically flanged frames

K = According to **Pt 3, Ch 1, Sec 4**

In no instance is $t_{REN,d/t}$ for lower integral brackets to be taken as less than $t_{REN,d/t}$ for the frames they support.

(a) Lower brackets
Lower brackets are to be flanged or face plate is to be fitted.
In calculating the web depth of the lower brackets, the following will apply:

The web depth of lower bracket may be measured from the intersection of the sloped bulkhead of the hopper tank and the side shell plate, perpendicularly to the face plate of the lower bracket (see Fig **7.3.24**).

Where stiffeners are fitted on the lower bracket plate, the web depth may be taken as the distance between the side shell and the stiffener, between the stiffeners or between the outermost stiffener and the face plate of the brackets, whichever is the greatest.

(b) Tripping bracket alternative

When t_M is less than $t_{REN,d/t}$ at section b) of the side frames, tripping brackets in accordance with **1702. 3** may be fitted as an alternative to the requirements for the web depth to thickness ratio of side frames, in which case $t_{REN,d/t}$ may be disregarded in the determination of t_{REN} in accordance with **1702. 1** (2).

(c) Immediately abaft collision bulkhead

For the side frames, including the lower bracket, located immediately abaft the collision bulkheads, whose scantlings are increased in order that their moment of inertia is such to avoid undesirable flexibility of the side shell, when their web as built thickness t_{AB} is greater than $1.65t_{REN,S}$, the thickness $t_{REN,d/t}$ may be taken as the value $t'_{REN,d/t}$ obtained from the following equation:

$$t'_{REN,d/t} = \sqrt[3]{t^2_{REN,d/t} \quad t_{REN,S}}$$

where, $t_{REN,S}$ is obtained from **1703. 3.**

(B) Thickness criteria based on shear strength check

Where t_M in the lower part of side frames, as defined in Fig **7.3.22**, is equal to or less than t_{COAT}, $t_{REN,S}$ is to be determined in accordance with **1703. 3.**

(C) Thickness of renewed webs of frames and lower brackets

Where steel renewal is required, the renewed webs are to be of a thickness not less than t_{AB}, $1.2t_{COAT}$ or $1.2t_{REN}$, whichever is the greatest.

(D) Criteria for other measures

When $t_{REN} < t_M \leq t_{COAT}$, measures are to be taken, consisting of all the following:

(a) sand blasting, or equivalent, and coating (see **1702. 2**),

(b) fitting tripping brackets (see **1702. 3**), when the above condition occurs for any of the side frame zones A, B, C and D, shown in Fig **7.3.22**, and

(c) maintaining the coating in "as-new" condition (i.e. without breakdown or rusting) at Special and Intermediate Surveys.

The above measures may be waived if the structural members show no thickness diminution with respect to the as built thicknesses and coating is in "as-new" condition (i.e. without breakdown or rusting).

When the measured frame webs thickness t_M is such that $t_{REN} < t_M \leq t_{COAT}$ and the coating is in GOOD condition, sand blasting and coating as required in (a) above may be waived even if not found in "as-new"condition, as defined above, provided that tripping brackets are fittted and the coating damaged in way of the tripping bracket welding is repaired.

(3) Criteria for frames and brackets (Bending check)

Where the length or depth of the lower bracket does not meet the requirements in **Sec 7**, a bending strength check in accordance with **1703. 4** is to be carried out and renewals or reinforcements of frames and/or brackets effected as required therein.

2. Thickness measurements, steel renewal, sand blasting and coating

(1) For the purpose of steel renewal, sand blasting and coating, four zones A, B, C and D are defined, as shown in **Fig 7.3.22.**

(2) Representative thickness measurements are to be taken for each zone and are to be assessed against the criteria in **1702. 1.**

(3) In case of integral brackets, when the criteria in **1702. 1** are not satisfied for zone A or B, steel renewal, sand blasting and coating, as applicable, are to be done for both zones A and B.

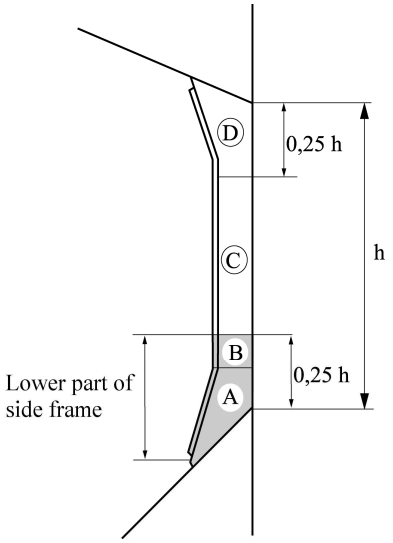
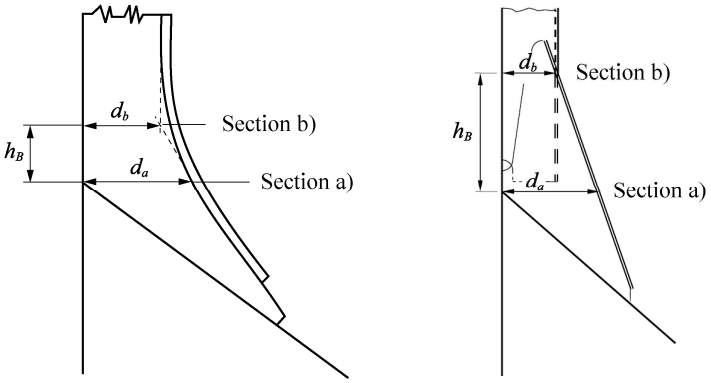


Fig 7.3.22 Lower part and zones of side frames



d_a = lower bracket web depth for determining $t_{REN,S}$

d_b = frame web depth

h_B = lower bracket length

Fig 7.3.23 Sections a) and b)

(4) In case of separate brackets, when the criteria in **1702. 1** are not satisfied for zone A or B, steel renewal, sand blasting and coating is to be done for each one of these zones, as applicable.

(5) When steel renewal is required for zone C according to **1702. 1**, it is to be done for both zones B and C. When sand blasting and coating is required for zone C according to **1702. 1**, it is to be done for zones B, C and D.

(6) When steel renewal is required for zone D according to **1702. 1**, it needs only to be done for this zone. When sand blasting and coating is required for zone D according to **1702. 1**, it is to be done for both zones C and D.

(7) Special consideration may be given by the Society to zones previously renewed or recoated, if found in "as-new" condition (i.e., without breakdown or rusting).

(8) When adopted, on the basis of the renewal thickness criteria in **1702. 1**, in general coating is to be applied in compliance with the requirements of **107.**, as applicable.

(9) Where, according to the requirements in **1702. 1,** a limited number of side frames and brackets are shown to require coating over part of their length, the following criteria apply.

(A) The part to be coated includes:
- the web and the face plate of the side frames and brackets,
- the hold surface of side shell, hopper tank and topside tank plating, as applicable, over a width not less than 100 mm from the web of the side frame.

(B) Epoxy coating or equivalent is to be applied.

(10) In all cases, all the surfaces to be coated are to be sand blasted prior to coating application.

(11) When flanges of frames or brackets are to be renewed according to this rule, the outstanding breadth to thickness ratio is to comply with the requirements in **701. 8.**

3. Reinforcing measures

(1) Reinforcing measures are constituted by tripping brackets, located at the lower part and at mid-span of side frames (see **Fig 7.3.25**). Tripping brackets may be located at every two frames, but lower and midspan brackets are to be fitted in line between alternate pairs of frames.

(2) The thickness of the tripping brackets is to be not less than the as-built thickness of the side frame webs to which they are connected.

(3) Double continuous welding is to be adopted for the connections of tripping brackets to the side shell frames and shell plating.

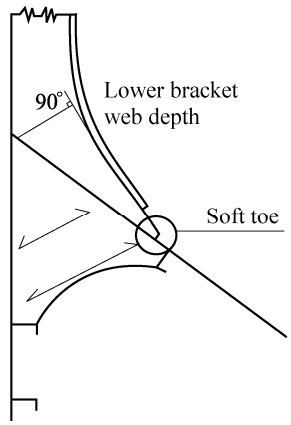


Fig 7.3.24 Definition of the lower bracket web depth for determining $t_{REN,d/t}$

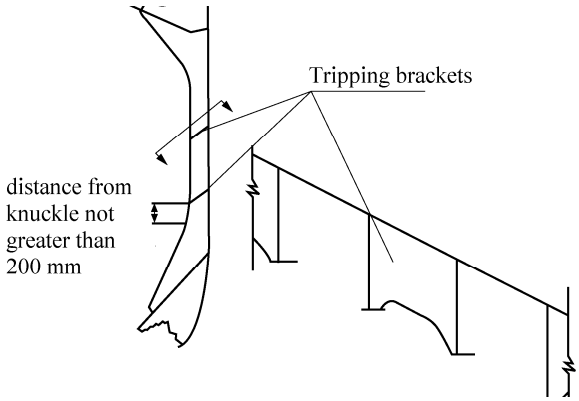


Fig 7.3.25 Tripping brackets

4. Weld throat thickness

In case of steel renewal the welded connections are to comply with **702. 4.**

5. Pitting and grooving

(1) If pitting intensity is higher than 15% in area (see **Fig 7.3.26**), thickness measurement is to be taken to check pitting corrosion.

(2) The minimum acceptable remaining thickness in pits or grooves is equal to:
- 75 % of the as built thickness, for pitting or grooving in the frame and brackets webs and flanges
- 70 % of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the side frame, over a width up to 30 mm from each side of it.

6. Renewal of all frames in one or more cargo holds

When all frames in one or more holds are required to be renewed according to this rule, the compliance with the requirements in **Sec. 7.** may be accepted in lieu of the compliance with the requirements in this rule, provided that:
- It is applied at least to all the frames of the hold(s)
- The coating requirements for side frames of "new ships" are complied with
- The section modulus of side frames is calculated according to this Society's rules.

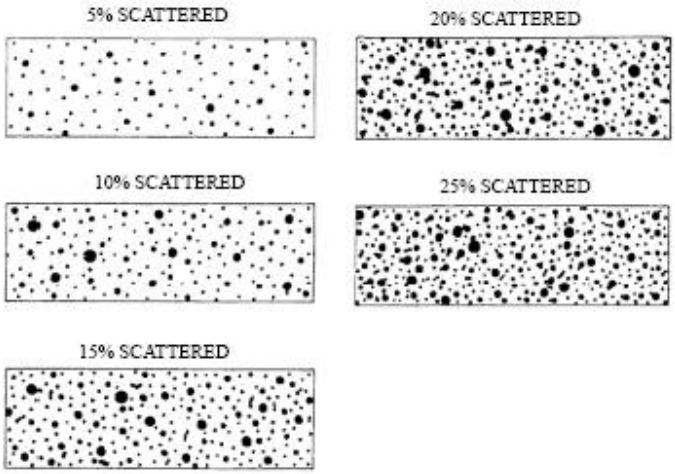


Fig 7.3.26 Pitting intensity diagrams (from 5% to 25% intensity)

1703. Strength check criteria 【See Guidance】

In general, loads are to be calculated and strength checks are to be carried out for the aft, middle and forward frames of each hold. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the above frames.
When scantlings of side frames vary within a hold, the required scantlings are also to be calculated for the mid frame of each group of frames having the same scantlings. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the calculated frames.

1. Load model

(1) Forces
The forces $P_{fr,a}$ and $P_{fr,b}\,(kN)$, to be considered for the strength checks at sections a) and b) of side frames (specified in Fig **7.3.23**; in the case of separate lower brackets, section b) is at the top of the lower bracket), are given by:

$$P_{fr,a} = P_S + \max(P_1, P_2)$$

$$P_{fr,b} = P_{fr,a}\frac{h-2h_B}{h}$$

where,

P_S = still water force (kN)

- when the upper end of the side frame span h (see Fig **7.3.22**) is below the load water line

$$P_S = Sh\left(\frac{p_{S,U}+p_{SL}}{2}\right)$$

- when the upper end of the side frame span h (see Fig **7.3.22**) is at or above the load water line

$$P_S = Sh'\left(\frac{p_{SL}}{2}\right)$$

P_1 = wave force (kN) in head sea

$$= Sh\left(\frac{p_{1,U}+p_{1,L}}{2}\right)$$

P_2 = wave force (kN) in beam sea

$$= Sh\left(\frac{p_{2,U}+p_{2,L}}{2}\right)$$

h, h_B = side frame span and lower bracket length (m) defined in Fig **7.3.22** and **7.3.23**, respectively

h' = distance (m) between the lower end of side frame span h (see Fig **7.3.22**) and the load water line

S = frame spacing (m)

$p_{S,U}, p_{S,L}$ = still water pressure (kN/m^2) at the upper and lower end of the side frame span h (see Fig **7.3.22**), respectively

$p_{1,U}, p_{1,L}$ = wave pressure (kN/m^2) as defined in **1703. 1** (2) (A) below for the upper and lower end of the side frame span h, respectively

$p_{2,U}, p_{2,L}$ = wave pressure (kN/m^2) as defined in **1703. 1** (2) (B) below for the upper and lower end of the side frame span h, respectively

(2) Wave Pressure

(A) Wave pressure p_1

The wave pressure p_1 (kN/m^2) at and below the waterline is given by:

$$p_1 = 1.50\left[p_{11} + 135\frac{B}{2(B+75)} - 1.2(T-z)\right]$$

$$p_{11} = 3k_s C + k_f$$

The wave pressure p_1 (kN/m^2) above the water line is given by:

$$p_1 = p_{1wl} - 7.50(z-T)$$

(B) Wave pressure p_2

The wave pressure p_2 (kN/m^2) at and below the waterline is given by

$$p_2 = 13.0\left[0.5B\frac{50C_r}{2(B+75)} + C_b\frac{0.5B+k_f}{14}(0.7+2\frac{z}{T})\right]$$

The wave pressure p_2 (kN/m^2) above the water line is given by:

$$p_2 = p_{2wl} - 5.0(z-T) \quad (kN/m^2)$$

where,

p_{1wl} = p_1 wave sea pressure at the waterline

p_{2wl} = p_2 wave sea pressure at the waterline

L = rule length (m) as defined in **Pt 3, Ch 1**

B = greatest moulded breadth (m)

C_b = block coefficient, as defined in **Pt 3, Ch 1**, but not to be taken less than 0.6

T = maximum design draught (m)

C = coefficient

= $10.75 - \left(\frac{300-L}{100}\right)^{1.5}$ for $90 \le L \le 300$ m

= 10.75 for $L > 300$ m

$$C_r = \left(1.25 - 0.025\frac{2k_r}{\sqrt{GM}}\right)k$$

k = 1.2 for ships without bilge keel

= 1.0 for ships with bilge keel

k_r = roll radius of gyration.

If the actual value of k_r is not available

= $0.39B$ for ships with even distribution of mass in transverse section (e.g. alternate heavy cargo loading or homogeneous light cargo loading)

= $0.25B$ for ships with uneven distribution of mass in transverse section (e.g. homogeneous heavy cargo distribution

GM = $0.12B$ if the actual value of GM is not available

z = vertical distance (m) from the baseline to the load point

k_s = $C_b + \frac{0.83}{\sqrt{C_b}}$ at aft end of L

= C_b between $0.2L$ and $0.6L$ from aft end of L

= $C_b + \frac{1.33}{\sqrt{C_b}}$ at forward end of L

Between the above specified points, k_s is to be interpolated linearly.

k_f = $0.8C$

2. Allowable stresses

The allowable normal and shear stresses σ_a and τ_a ($\mathrm{N/mm^2}$) in the side shell frames and brackets are given by:

$$\sigma_a = 0.9\sigma_y$$
$$\tau_a = 0.4\sigma_y$$

where σ_y is the minimum upper yield stress ($\mathrm{N/mm^2}$) of the material.

3. Shear strength check

Where t_M in the lower part of side frames, as defined in Fig **7.3.22**, is equal to or less than t_{COAT}, shear strength check is to be carried out in accordance with the following. The thickness $t_{REN,S}$ (mm), is the greater of the thicknesses $t_{REN,Sa}$ and $t_{REN,Sb}$ obtained from the shear strength check at sections a) and b) (see Fig **7.3.23** and **1703. 1**) given by the following, but need not be taken in excess of $0.75t_{S12}$.

- at section a) : $t_{REN,Sa} = \frac{1000\,k_s P_{fr,a}}{d_a \sin\phi\, \tau_a}$ (mm)

- at section b) : $t_{REN,Sa} = \frac{1000\,k_s P_{fr,b}}{d_b \sin\phi\, \tau_a}$ (mm)

where:

k_s : shear force distribution factor, to be taken equal to 0,6

$P_{fr,a}$, $P_{fr,b}$: pressures forces defined in **1703. 1**

d_a, d_b : bracket and frame web depth (mm) at sections a) and b), respectively (see **Fig 7.3.23**); in case of separate (non integral) brackets, d_b is to be taken as the minimum web depth deducing possible scallops

ϕ : angle between frame web and shell plate

τ_a : allowable shear stress ($\mathrm{N/mm^2}$) defined in **1703. 2**

4. Bending strength check

(1) Where the lower bracket length or depth does not meet the requirements in **Sec 7**, the actual section modulus (cm^3) of the brackets and side frames at sections a) and b) is to be not less than:

- at section a) : $Z_a = \dfrac{1000\,P_{fr,a}\,h}{m_a\sigma_a} \quad (\mathrm{cm}^3)$

- at section b) : $Z_b = \dfrac{1000\,P_{fr,a}\,h}{m_b\sigma_a} \quad (\mathrm{cm}^3)$

where,

$P_{fr,a}$ = pressures force defined in **1703. 1**

h = side frame span (m) defined in Fig **7.3.22**

σ_a = allowable normal stress ($\mathrm{N/mm^2}$) defined in **1703. 2**

m_a, m_b = bending moment coefficients defined in **Table 7.3.13**

(2) The actual section modulus of the brackets and side frames is to be calculated about an axis parallel to the attached plate, based on the measured thicknesses. For precalculations, alternative thickness values may be used, provided they are not less than:

- t_{REN} for the web thickness
- the minimum thicknesses allowed by the Society renewal criteria for flange and attached plating.

(3) The attached plate breadth is equal to the frame spacing, measured along the shell at midspan of h.

(4) If the actual section moduli at sections a) and b) are less than the values Z_a and Z_b, the frames and brackets are to be renewed or reinforced in order to obtain actual section moduli not less than $1.2\,Z_a$ and $1.2\,Z_b$, respectively.

(5) In such a case, renewal or reinforcements of the flange are to be extended over the lower part of side frames, as defined in Fig **7.3.22**.

Table 7.3.13 Bending moment coefficients m_a and m_b

	m_a	m_b		
		$h_B = 0.08h$	$h_B = 0.1\,h$	$h_B = 0.125\,h$
Empty holds of ships approved to operate in non homogeneous loading conditions	10	17	19	22
Other cases	12	20	22	26

Note
1. Non homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, exceeds 1.20 corrected for different cargo densities.
2. For intermediate values of the bracket length h_B, the coefficient m_b is obtained by linear interpolation between the table values.

Section 18 Cargo Hatch Cover Securing Arrangements

1801. Application and implementation

1. These requirements apply to all bulk carriers which were not built in accordance with **Sec 9** and are for steel hatch cover securing devices and stoppers for cargo hold hatchways No.1 and No.2 which are wholly or partially within 0.25L of the fore perpendicular, except pontoon type hatch cover.
2. All bulk carriers not built in accordance with **Sec 9** are to comply with the requirements in accordance with **Pt 1, Ch 3, 201.** (6)
3. All bulk carriers not built in accordance with **Sec 9** and in order to postpone these requirements are to be followed **Pt 1, Ch 3, 201.** (6).
4. These requirements are not applicable to SUBC(Self-Unloading Bulk Carrier). *(2020)*

1802. Securing devices

1. The strength of securing devices is to comply with the following requirements:
2. 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.
3. The net sectional area of each securing device is not to be less than:

$$A = 1.4\, a/f \quad (\mathrm{cm}^2)$$

a = spacing between securing devices not to be taken less than 2 m

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

σ_y = specified minimum upper yield stress $(\mathrm{N/mm^2})$ of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.

$e = 0.75$ for $\sigma_y > 235$

$= 1.0$ for $\sigma_y \leq 235$

4. Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 $\mathrm{m^2}$ in area.
5. Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weather tightness is to be maintained by the securing devices.
6. For packing line pressures exceeding 5 $\mathrm{N/mm}$, the cross section area is to be increased in direct proportion. The packing line pressure is to be specified.
7. 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:

$$I = 6\, p\, a^4 \quad (\mathrm{cm}^4)$$

where,

p : packing line pressure $(\mathrm{N/mm})$, minimum 5 $\mathrm{N/mm}$

a : spacing (m) of securing devices.

8. 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.

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

10. 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.

1803. Stoppers

1. No. 1 and 2 hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 $\mathrm{kN/m^2}$.

2. No. 2 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 $\mathrm{kN/m^2}$.

3. 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 $\mathrm{kN/m^2}$. This pressure may be reduced to 175 $\mathrm{kN/m^2}$ if a forecastle is fitted.

4. The equivalent stress in stoppers and their supporting structures, and calculated in the throat of the stopper welds is not to exceed the allowable value of $0.8\sigma_y$.

1804. Materials and welding

Where stoppers or securing devices are fitted to comply with the these requirements, they are to be manufactured of materials, including welding electrodes, meeting the relevant requirements. ⚓

CHAPTER 4 CONTAINER SHIPS

Section 1 General

101. Application 【See Guidance】

1. The construction and equipment of ships intended to be registered and classed as "Container Ship" are to be in accordance with the requirements in this Chapter, where, "Container Ship" means a ship designed exclusively for the carriage of containers in holds and on deck.
2. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.
3. The requirements in this Chapter apply to ships which are single deckers having double bottoms in cargo holds and having decks and bottoms framed longitudinally.
4. The container ships with different type from that specified in **Par 3** to which the requirements in this Chapter are not applicable, are to be at the discretion of the Society.
5. In case of the container ships with "SeaTrust(FSA3)" notation of direct fatigue analysis method for the fatigue strength assessment of ship structures in **Pt 3, Annex 3-3**, 0.66 value of material factor, K on YP40 steel may be taken. However, in addition to **Table 9** in **Pt 3, Annex 3-3**, butt welds in the hatch side coaming and fillet welded joints for fixing outfitting items and etc. may be included in the locations for the fatigue strength assessment.
6. For container ships contracted for construction on or after July 1, 2018, the requirements in **Pt 14 Structural Rules for Container Ships** are applied. *(2021)*

102. Direct Strength Calculation

1. This regulation applies to container ships and ships dedicated primarily to carry their cargo in containers.
2. The procedure for yielding and buckling assessment are to be in accordance with the requirements in **Pt 3, Annex 3-2.**
3. Definitions
   (1) A Global Analysis is a finite element analysis, using a full ship model, for assessing the structural strength of global hull girder structure, cross deck structures and hatch corner radii.
   (2) A Cargo Hold Analysis is a finite element analysis for assessing the structural strength of the cargo hold primary structural members(PSM) in the midship region. Primary structural members are members of girder or stringer type which provide the overall structural integrity of the hull envelope and cargo hold boundaries, such as:
   (a) double bottom structure(bottom plate, inner bottom plate, girders, floors)
   (b) double side structure(shell plating, inner hull, stringers and web frames)
   (c) bulkhead structure
   (d) deck and cross deck structure
4. Analysis
   (1) A Global Analysis is to be carried out for ships of length 290 m or above. Hull girder loads(including torsional effects) are to be considered in accordance with the requirements in **Pt 3, Annex 3-2 II.**
   (2) Cargo Hold Analysis is to be carried out for ships of length 150 m or above. Local loads such as sea pressure and container loads as well as hull girder loads are to be considered in accordance with the requirements in **Pt 3, Annex 3-2 III. 5.**
   (3) In case of ships other than those specified in (1) or (2), where deemed necessary by the Society, a Global Analysis and/or Cargo Hold Analysis may be performed.

103. Application of extremely thick steel plates with high yield strength *(2021)*

1. Where extremely thick plates with high yield strength are used for hull construction, the application is to be in accordance with the **Annex 7-8 「Instruction for Use of Extremely Thick Steel Plates」.**

Section 2 Longitudinal Strength

201. General

1. Application

(1) Application

This regulation applies to the following types of steel ships with a length L of 90 m and greater and operated in unrestricted service:

(a) Container ships

(b) Ships dedicated primarily to carry their load in containers

(2) Load limitations

The wave induced load requirements apply to monohull displacement ships in unrestricted service and are limited to ships meeting the following criteria:

(a) Length 90 m ≤ L ≤ 500 m

(b) Proportion 5 ≤ L/B ≤ 9; 2 ≤ B/T ≤ 6

(c) Block coefficient at scantling draught 0.55 ≤ C_B ≤ 0.9

For ships that do not meet all of the aforementioned criteria, direct calculations of wave induced loads may be considered in accordance with the requirements in **Pt 3, Annex 3-2.**

(3) Longitudinal extent of strength assessment

The stiffness, yield strength, buckling strength and hull girder ultimate strength assessment are to be carried out in way of 0.2L to 0.75L with due consideration given to locations where there are significant changes in hull cross section, e.g. changing of framing system and the fore and aft end of the forward bridge block in case of two-island designs. In addition, strength assessments are to be carried out outside this area. As a minimum assessments are to be carried out at forward end of the foremost cargo hold and the aft end of the aft most cargo hold. Evaluation criteria used for these assessments are determined by the Society.

2. Symbols and definitions

(1) symbols

L : Rule length (m), as defined in **Pt 3, Ch 1, 102.**

B : Moulded breadth (m)

C : Wave parameter, see **202. 3.** (1)

T : Scantling draught (m)

C_B : Block coefficient at scantling draught

C_W : Waterplane coefficient at scantling draught, to be taken as: $C_W = A_W/(LB)$

A_W : Waterplane area at scantling draught (m^2)

R_{eH} : Specified minimum yield stress of the material (N/mm^2)

k : Material factor as defined in **Pt 3, Ch 1, 403.** for higher tensile steels, k=1.0 for mild steel having a minimum yield strength equal to 235 N/mm^2

E : Young's modulus (N/mm^2), to be taken as E = 2.06×105 for steel

M_S : Vertical still water bending moment in seagoing condition (kNm), at the cross section under consideration

$M_{S\max}$, $M_{S\min}$: Permissible maximum and minimum vertical still water bending moments in seagoing condition (kNm), at the cross section under consideration, see **202. 2.** (2)

M_W : Vertical wave induced bending moment (kNm), at the cross section under consideration

F_S : Vertical still water shear force in seagoing condition (kN), at the cross section under consideration

$F_{S\max}$, $F_{S\min}$: Permissible maximum and minimum still water vertical shear force in seagoing condition (kN), at the cross section under consideration, see **202. 2.** (2)

F_W : Vertical wave induced shear force (kN), at the cross section under consideration

q_V : Shear flow along the cross section under consideration, to be determined according to **Appendix 1**

f_{NL-Hog} : Non-linear correction factor for hogging, see **202. 3.** (2)

f_{NL-Sag} : Non-linear correction factor for sagging, see **202. 3.** (2)

f_R : Factor related to the operational profile, see **202. 3.** (2)

t_{net} : Net thickness (mm), see **3.** (1)

t_{res} : Reserve thickness, to be taken as 0.5mm

I_{net} : Net vertical hull girder moment of inertia at the cross section under consideration, to be determined using net scantlings (m^4), as defined in **3.**

σ_{HG} : Hull girder bending stress $(\mathrm{N/mm^2})$, as defined in **202. 5.**

τ_{HG} : Hull girder shear stress $(\mathrm{N/mm^2})$, as defined in **202. 5.**

x : Longitudinal co-ordinate of a location under consideration (m)

z : Vertical co-ordinate of a location under consideration (m)

z_n : Distance from the baseline to the horizontal neutral axis (m)

(2) Fore end and aft end

The fore end (FE) of the rule length L, see **Fig 7.4.1**, is the perpendicular to the scantling draught waterline at the forward side of the stem.

The aft end (AE) of the rule length L, see **Fig 7.4.1**, is the perpendicular to the scantling draught waterline at a distance L aft of the fore end (FE).

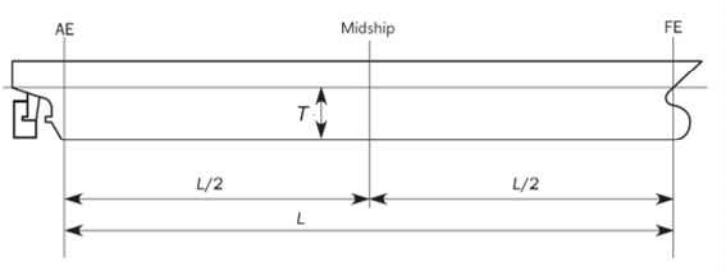


Fig 7.4.1 Ends of length L

(3) Reference coordinate system

The ships geometry, loads and load effects are defined with respect to the following right-hand coordinate system (see **Fig 7.4.2**):

Origin : At the intersection of the longitudinal plane of symmetry of ship, the aft end of L and the baseline

X axis : Longitudinal axis, positive forwards

Y axis : Transverse axis, positive towards portside

Z axis : Vertical axis, positive upwards

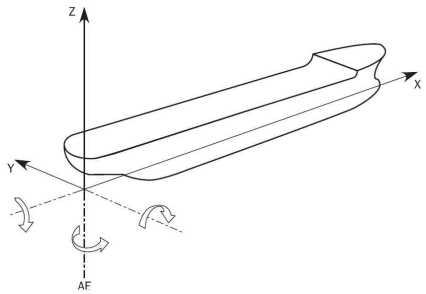


Fig 7.4.2 Reference coordinate system

3. Corrosion margin and net thickness

(1) Net scantling definitions

The strength is to be assessed using the net thickness approach on all scantlings. The net thickness, t_{net} for the plates, webs and flanges is obtained by subtracting the voluntary addition, t_{vol_add} and the factored corrosion addition, t_c (mm) from the as built thickness, t_{as_built}, as follows:

$$t_{net} = t_{as\_built} - t_{vol\_add} - \alpha t_c$$

where α is a corrosion addition factor whose values are defined in **Table 7.4.1**. The voluntary addition, if being used, is to be clearly indicated on the drawings.

Table 7.4.1 Values of corrosion addition factor

Structural requirement	Property / analysis type	α
Strength ssessment (203.)	Section properties	0.5
Buckling strength (204.)	Section properties (stress determination)	0.5
	Buckling capacity	1.0
Hull girder ultimate strength (206.)	Section properties	0.5
	Buckling / collapse capacity	0.5

(2) Determination of corrosion addition

The corrosion addition for each of the two sides of a structural member, t_{c1} or t_{c2} is specified in **Table 7.4.2**. The total corrosion addition, t_c for both sides of the structural member is obtained by the following formula:

$$t_c = (t_{c1} + t_{c2}) + t_{res}$$

For an internal member within a given compartment, the total corrosion addition, t_c is obtained from the following formula:

$$t_c = (2t_{c1}) + t_{res}$$

The corrosion addition of a stiffener is to be determined according to the location of its connection to the attached plating.

Table 7.4.2 Corrosion addition for one side of a structural member

Compartment type	One side corrosion addition t_{c1} or t_{c2} [mm]
Exposed to sea water	1.0
Exposed to atmosphere	1.0
Ballast water tank	1.0
Void and dry spaces	0.5
Fresh water, fuel oil and lube oil tank	0.5
Accommodation spaces	0.0
Container holds	1.0
Compartment types not mentioned above	0.5

(3) Determination of net section properties
The net section modulus, moment of inertia and shear area properties of a supporting member are to be calculated using the net dimensions of the attached plate, web and flange, as defined in **Fig 7.4.3**. The net cross-sectional area, the moment of inertia about the axis parallel to the attached plate and the associated neutral axis position are to be determined through applying a corrosion magnitude of $0.5\,\alpha t_c$ deducted from the surface of the profile cross-section.

202. Loads

1. Sign convention for hull girder loads

The sign conventions of vertical bending moments and vertical shear forces at any ship transverse section are as shown in **Fig 7.4.4**, namely:

- The vertical bending moments M_S and M_W are positive when they induce tensile stresses in the strength deck (hogging bending moment) and negative when they induce tensile stresses in the bottom (sagging bending moment).
- The vertical shear forces F_S, F_W are positive in the case of downward resulting forces acting aft of the transverse section and upward resulting forces acting forward of the transverse section under consideration. The shear forces in the directions opposite to above are negative.

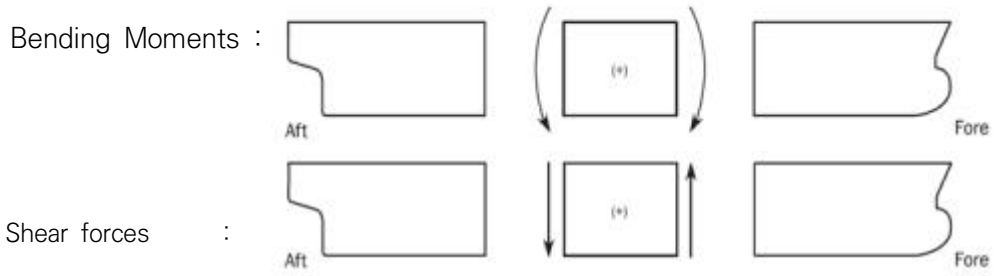


Fig 7.4.4 Sign conventions of bending moments and shear forces

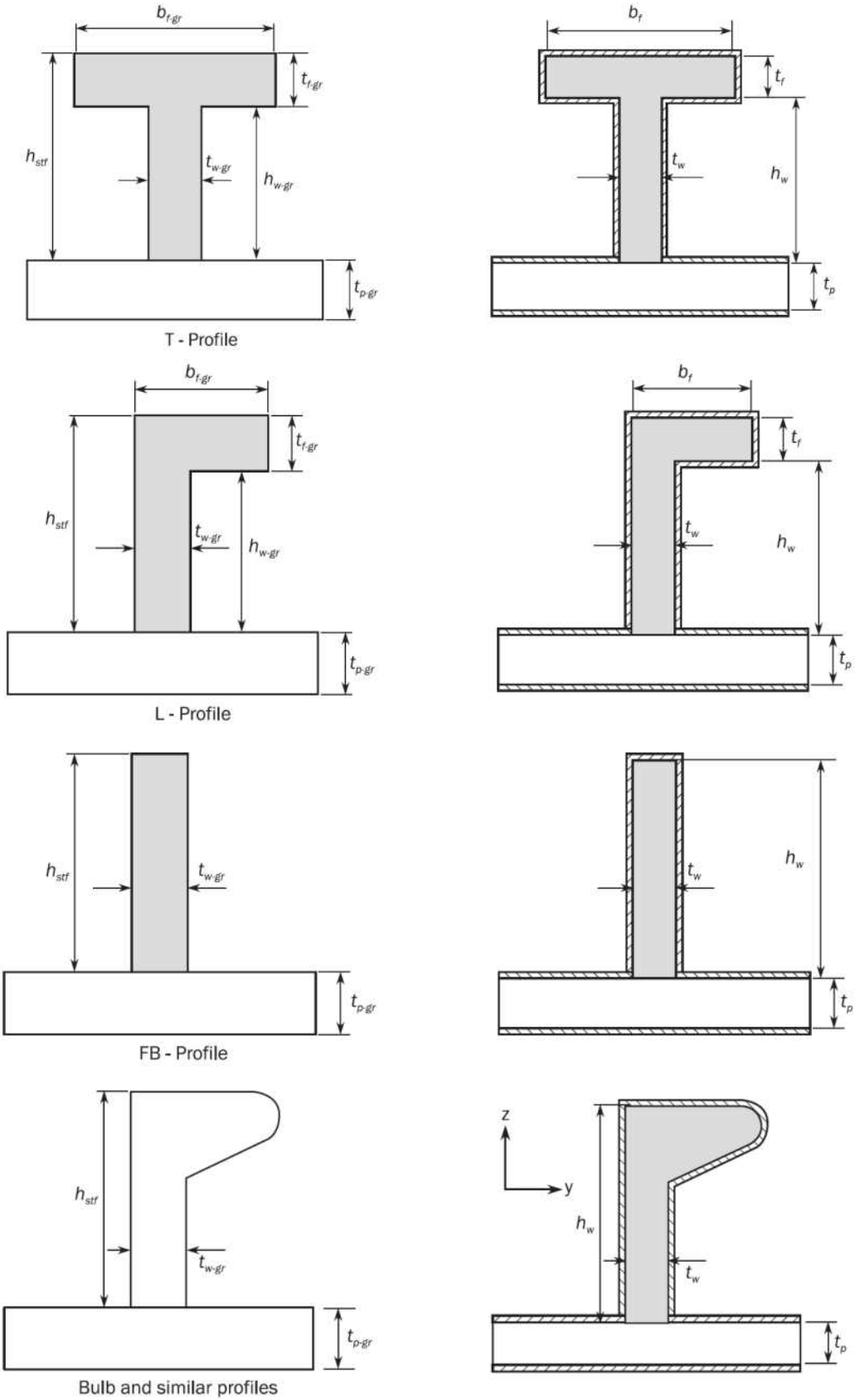


Fig 7.4.3 Net sectional properties of supporting mem

2. Still water bending moments and shear forces

(1) General

Still water bending moments, M_S(kNm) and still water shear forces, F_S(kN) are to be calculated at each section along the ship length for design loading conditions as specified in **202. 2.** (2).

(2) Design loading conditions

In general, the design cargo and ballast loading conditions, based on amount of bunker, fresh water and stores at departure and arrival, are to be considered for the M_S and F_S calculations. Where the amount and disposition of consumables at any intermediate stage of the voyage are considered more severe, calculations for such intermediate conditions are to be submitted in addition to those for departure and arrival conditions. Also, where any ballasting and/or de-ballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or de-ballasting any ballast tank are to be submitted and where approved included in the loading manual for guidance. The permissible vertical still water bending moments $M_{S\max}$, $M_{S\min}$ and the permissible vertical still water shear forces $F_{S\max}$, $F_{S\min}$ in seagoing conditions at any longitudinal position are to envelop:

- The maximum and minimum still water bending moments and shear forces for the seagoing loading conditions defined in the Loading Manual.
- The maximum and minimum still water bending moments and shear forces specified by the designer. The Loading Manual should include the relevant loading conditions, which envelop the still water hull girder loads for seagoing conditions, including those specified in **Pt 3, Annex 3-2.**

3. Wave loads

(1) Wave parameter

The wave parameter is defined as follows:

$$C = 1 - 1.50\left(1 - \sqrt{\frac{L}{L_{ref}}}\right)^{2.2} \quad \text{for } L \leq L_{ref}$$

$$C = 1 - 0.45\left(\sqrt{\frac{L}{L_{ref}}} - 1\right)^{1.7} \quad \text{for } L > L_{ref}$$

where:

L_{ref} Reference length (m), taken as:

$L_{ref} = 315\, C_W^{-1.3}$ for the determination of vertical wave bending moments according to **202. 3.** (2).

$L_{ref} = 330\, C_W^{-1.3}$ for the determination of vertical wave shear forces according to **202. 3.** (3).

(2) Vertical wave bending moments

The distribution of the vertical wave induced bending moments, M_W(kNm) along the ship length is given in **Fig 7.4.6**, where:

$$M_{W-Hog} = +1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Hog}$$

$$M_{W-Sag} = -1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Sag}$$

where:

f_R : Factor related to the operational profile, to be taken as:

$f_R = 0.85$

f_{NL-Hog} : Non-linear correction for hogging, to be taken as:

$$f_{NL-Hog} = 0.3\frac{C_B}{C_W}\sqrt{T} \qquad \text{not to be taken greater than 1.1}$$

f_{NL-Sag} : Non-linear correction for sagging, to be taken as:

$$f_{NL-Sag} = 4.5\frac{1+0.2f_{Bow}}{C_W\sqrt{C_B}\,L^{0.3}} \qquad \text{not to be taken less than 1.0}$$

f_{Bow} : Bow flare shape coefficient, to be taken as:

$$f_{Bow} = \frac{A_{DK}-A_{WL}}{0.2\,L\,Z_f}$$

A_{DK} : Projected area in horizontal plane of uppermost deck (m^2) including the forecastle deck, if any, extending from $0.8L$ forward (see **Fig 7.4.5**). Any other structures, e.g. plated bulwark, are to be excluded.

A_{WL} : Waterplane area (m^2), at draught T, extending from $0.8L$ forward

Z_f : Vertical distance (m), from the waterline at draught T to the uppermost deck (or forecastle deck), measured at FE (see **Fig 7.4.5**). Any other structures, e.g. plated bulwark, are to be excluded.

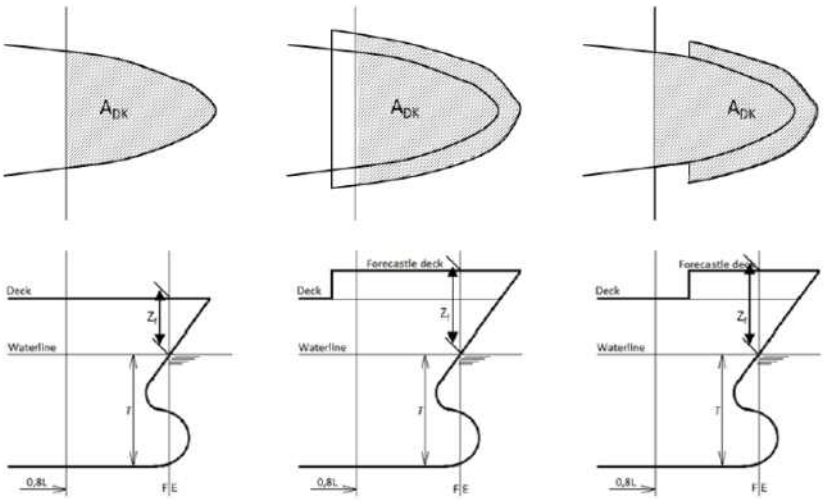


Fig 7.4.5 Projected area ADK and vertical distance zf

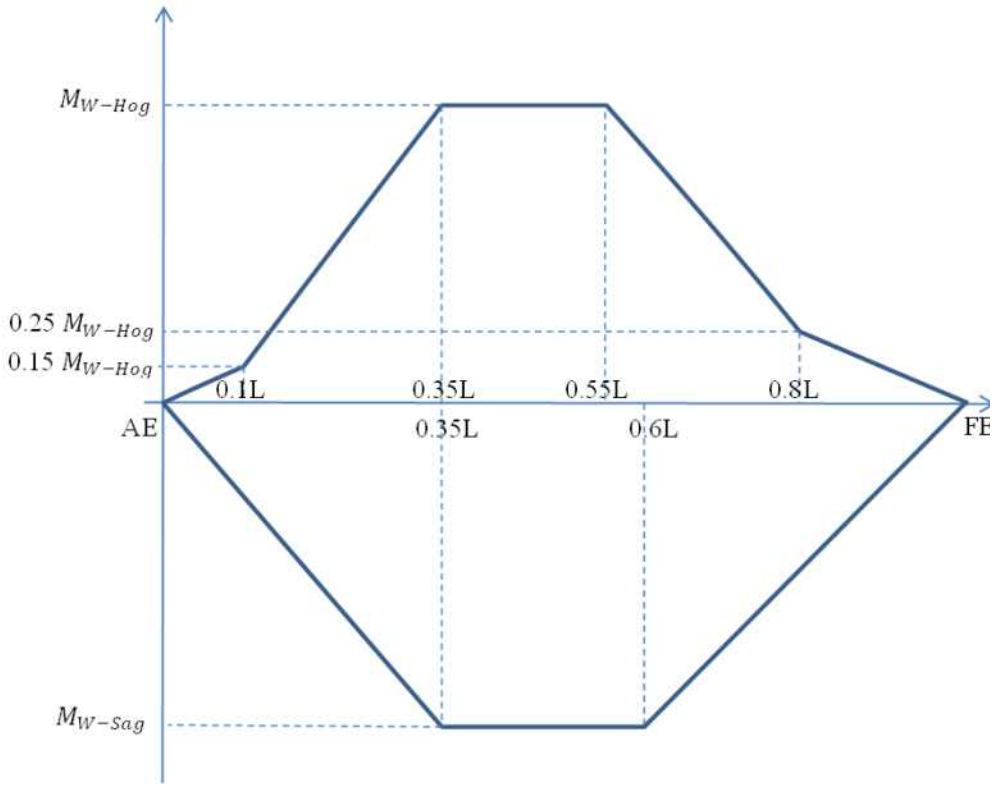


Fig 7.4.6 Distribution of vertical wave bending moment MW along the ship length

(3) Vertical wave shear force

The distribution of the vertical wave induced shear forces, F_W(kN), along the ship length is given in **Fig 7.4.7**, where,

$$F_{W\,Hog}^{Aft} = +5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.3 + 0.7 f_{NL-Hog})$$

$$F_{W\,Hog}^{Fore} = -5.7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Hog}$$

$$F_{W\,Sag}^{Aft} = -5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.3 + 0.7 f_{NL-Sag})$$

$$F_{W\,Sag}^{Fore} = +5.7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.25 + 0.75 f_{NL-Sag})$$

$$F_W^{Mid} = +4.0 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8}$$

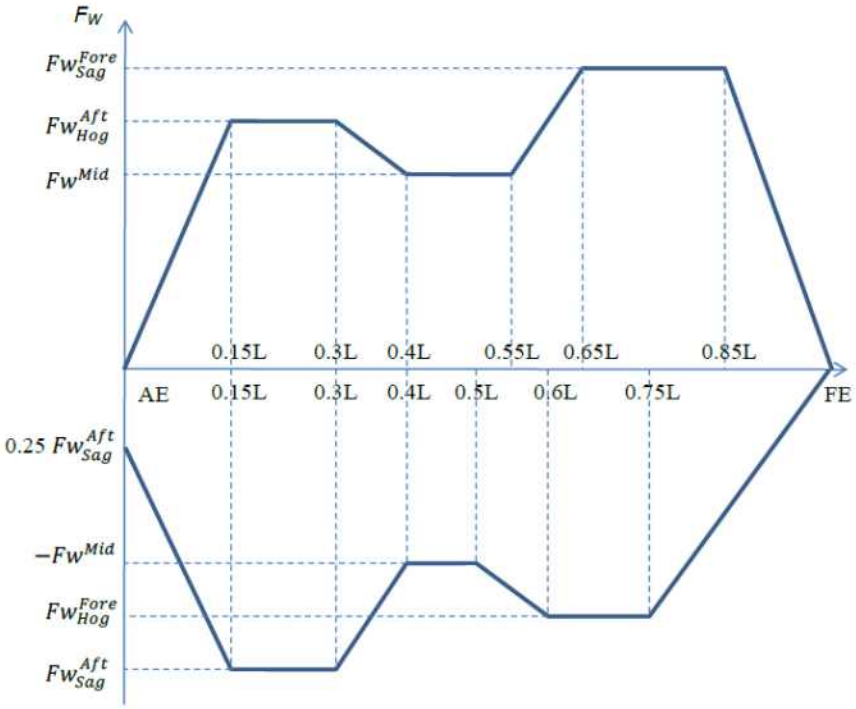


Fig 7.4.7 Distribution of vertical wave shear force FW along the ship length

4. Load cases

For the strength assessment, the maximum hogging and sagging load cases given in **Table 7.4.3** are to be checked. For each load case the still water condition at each section as defined in **2.** is to be combined with the wave condition as defined in **3.** refer also to **Fig 7.4.8.**

Table 7.4.3 Combination of still water and wave bending moments and shear forces

Load case	Bending moment		Shear force	
	M_S	M_W	F_S	F_W
Hogging	$M_{S\max}$	M_{WH}	$F_{S\max}$ for x ≤ 0.5L	$F_{W\max}$ for x ≤ 0.5L
			$F_{S\min}$ for x 〉 0.5L	$F_{W\min}$ for x 〉 0.5L
Sagging	$M_{S\min}$	M_{WS}	$F_{S\min}$ for x ≤ 0.5L	$F_{W\min}$ for x ≤ 0.5L
			$F_{S\max}$ for x 〉 0.5L	$F_{W\max}$ for x 〉 0.5L

M_{WH} : Wave bending moment in hogging at the cross section under consideration, to be taken as the positive value of M_W as defined in Fig 7.4.6.

M_{WS} : Wave bending moment in sagging at the cross section under consideration, to be taken as the negative value of M_W as defined Fig 7.4.6.

$F_{W\max}$: Maximum value of the wave shear force at the cross section under consideration, to be taken as the positive value of F_W as defined Fig 7.4.7.

$F_{W\min}$: Minimum value of the wave shear force at the cross section under consideration, to be taken as the negative value of F_W as defined Fig 7.4.7.

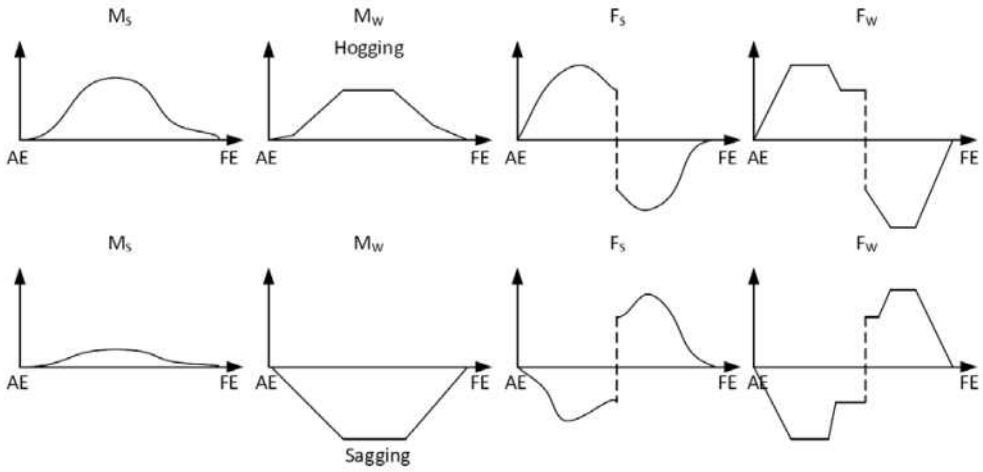


Fig 7.4.8 Load combination to determine the maximum hogging and sagging load cases as given in Table 7.4.3

5. Hull girder stress

The hull girder stresses (N/mm^2) are to be determined at the load calculation point under consideration, for the "hogging" and "sagging" load cases defined in **4.** as follows:

Bending stress : $\sigma_{HG} = \dfrac{\gamma_S M_S + \gamma_W M_W}{I_{net}} (z - z_n) 10^{-3}$

Shear stress : $\tau_{HG} = \dfrac{\gamma_S F_S + \gamma_W F_W}{t_{net}/q_v} 10^3$

where:

γ_S, γ_W : Partial safety factors, to be taken as:

$\gamma_S = 1.0$

$\gamma_W = 1.0$

203. Strength assessment

1. General

Continuity of structure is to be maintained throughout the length of the ship. Where significant changes in structural arrangement occur adequate transitional structure is to be provided.

2. Stiffness criteria

The two load cases "hogging" and "sagging" as listed in **202. 4.** are to be checked. The net moment of inertia (m^4), is not to be less than:

$$I_{net} \geq 1.55 L \left| M_S + M_W \right| 10^{-7}$$

3. Yield strength assessment

(1) General acceptance criteria

The yield strength assessment is to check, for each of the load cases "hogging" and "sagging" as defined in **202. 4.** that the equivalent hull girder stress, σ_{eq} (N/mm^2) is less than the permissible stress, σ_{perm} (N/mm^2), as follows:

$$\sigma_{eq} < \sigma_{perm}$$

where:

$$\sigma_{eq} = \sqrt{\sigma_x^2 + 3\tau^2}$$

$$\sigma_{perm} = \frac{R_{eH}}{\gamma_1 \gamma_2}$$

γ_1 : Partial safety factor for material, to be taken as: $\gamma_1 = k\,\frac{R_{eH}}{235}$

γ_2 : Partial safety factor for load combinations and permissible stress, to be taken as:

$\gamma_2 = 1.24$, for bending strength assessment according to **3.3.2.**

$\gamma_2 = 1.13$, for shear stress assessment according to **3.3.3.**

(2) Bending strength assessment

The assessment of the bending stresses is to be carried out according to (1) at the following locations of the cross section:

- At bottom
- At deck
- At top of hatch coaming
- At any point where there is a change of steel yield strength

The following combination of hull girder stress as defined in **202. 5** is to be considered:

$\sigma_x = \sigma_{HG}$

$\tau = 0$

(3) Shear strength assessment

The assessment of shear stress is to be carried out according to (1) for all structural elements that contribute to the shear strength capability. The following combination of hull girder stress as defined in **202. 5** is to be considered:

$\sigma_x = 0$

$\tau = \tau_{HG}$

204. Buckling strength 【See Guidance】

1. Application

These requirements apply to plate panels and longitudinal stiffeners subject to hull girder bending and shear stresses. Definitions of symbols used in the present article are given in **Annex 7-9, Appendix 2.**

2. Buckling criteria

The acceptance criterion for the buckling assessment is defined as follows:

$$\eta_{act} \leq 1$$

where:

η_{act} : Maximum utilisation factor as defined in **3.**

3. Buckling utilisation factor

The utilisation factor, η_{act} is defined as the inverse of the stress multiplication factor at failure, γ_c, see **Fig 7.4.9**.

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

Failure limit states are defined in:

- **Annex 7-9, Appendix 2. 2** for elementary plate panels
- **Annex 7-9, Appendix 2. 3** for overall stiffened panels
- **Annex 7-9, Appendix 2. 4** for longitudinal stiffeners

Each failure limit state is defined by an equation, and γ_c is to be determined such that it satisfies the equation. **Fig 7.4.9** illustrates how the stress multiplication factor at failure, γ_c of a structural member is determined for any combination of longitudinal and shear stress.

Where:

σ_x, τ : Applied stress combination for buckling given in **4.**

σ_c, τ_c : Critical buckling stresses to be obtained according to **Annex 7-9, Appendix 2** for the stress combination for buckling σ_x and τ.

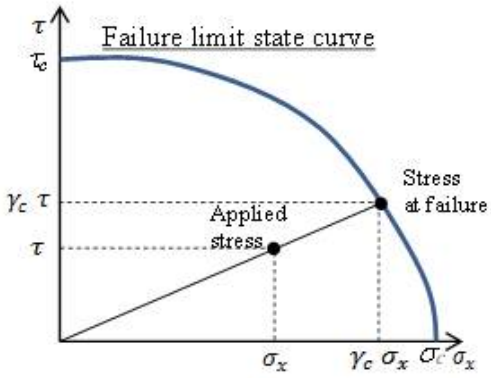


Fig 7.4.9 Example of failure limit state curve and stress multiplication factor at failure

4. Stress determination

(1) Stress combinations for buckling assessment
The following two stress combinations are to be considered for each of the load cases "hogging" and "sagging" as defined in **202. 4**. The stresses are to be derived at the load calculation points defined in (2)

(a) Longitudinal stiffening arrangement:

Stress combination 1 with:

$$\sigma_x = \sigma_{HG}$$
$$\sigma_y = 0$$
$$\tau = 0.7\tau_{HG}$$

Stress combination 2 with:

$$\sigma_x = 0.7\sigma_{HG}$$
$$\sigma_y = 0$$
$$\tau = \tau_{HG}$$

(b) Transverse stiffening arrangement:

Stress combination 1 with:

$$\sigma_x = 0$$
$$\sigma_y = \sigma_{HG}$$
$$\tau = 0.7\tau_{HG}$$

Stress combination 2 with:

$$\sigma_x = 0$$
$$\sigma_y = 0.7\sigma_{HG}$$
$$\tau = \tau_{HG}$$

(2) Load calculation point
The hull girder stresses for elementary plate panels (EPP) are to be calculated at the load calculation points defined in **Table 7.4.4.**

Table 7.4.4 Load calculation points (LCP) coordinates for plate buckling assessment

LCP coordinates	Hull girder bending stress		Hull girder shear stress
	Non horizontal plating	Horizontal plating	
x coordinate	Mid-length of the EPP		
y coordinate	Both upper and lower ends of the EPP(points A1 and A2 in **Fig 7.4.10**)	Outboard and inboard ends of the EPP(points A1 and A2 in **Fig 7.4.10**)	Mid-point of EPP (point B in **Fig 7.4.10**)
z coordinate	Corresponding to x and y values		

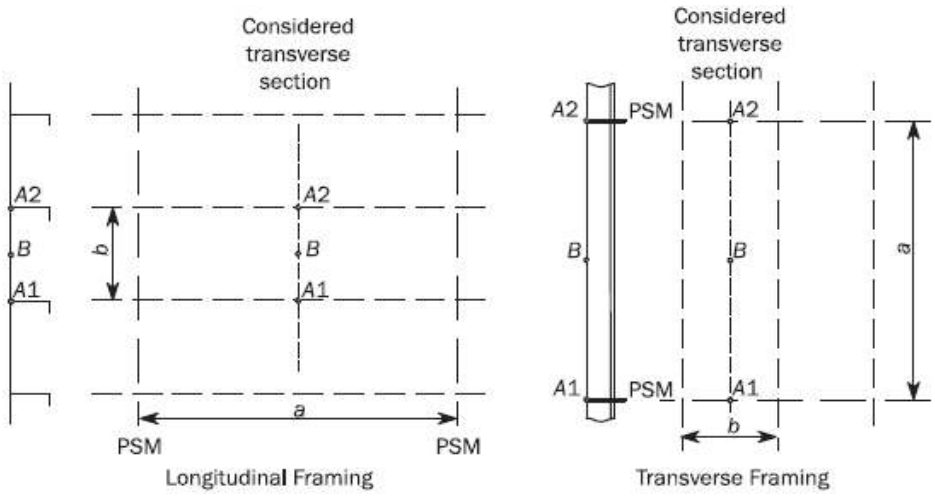


Fig 7.4.10 LCP for plate buckling - assessment, PSM stands for primary supporting members

The hull girder stresses for longitudinal stiffeners are to be calculated at the following load calculation point:
- at the mid length of the considered stiffener.
- at the intersection point between the stiffener and its attached plate.

205. Torsional strength 【See Guidance】

Where the width of hatchway at midship exceeds $0.7B$, special considerations are to be paid to the additional stress and the deformation of hatchway openings due to torsion. Where, however, the ship has two or more rows of hatchways, the distance between the outermost lines of hatchway openings is to be taken as the width of hatchway.

206. Hull girder ultimate strength

1. Application

The hull girder ultimate strength is to be assessed for ships with length, L equal or greater than 150m. The acceptance criteria, given in **4.** are applicable to intact ship structures. The hull girder ultimate bending capacity is to be checked for the load cases "hogging" and "sagging" as defined in **202. 4**.

2. Hull girder ultimate bending moments

The vertical hull girder bending moment, M in hogging and sagging conditions, to be considered in the ultimate strength check is to be taken as:

$$M = \gamma_S M_S + \gamma_W M_W$$

where:

M_S = Permissible still water bending moment (kNm), defined in **202. 4**

M_W = Vertical wave bending moment (kNm), defined in **202. 4**

γ_S = Partial safety factor for the still water bending moment, to be taken as 1.0

γ_W = Partial safety factor for the vertical wave bending moment, to be taken as 1.2

3. Hull girder ultimate bending capacity

(1) General The hull girder ultimate bending moment capacity, M_U is defined as the maximum bending moment capacity of the hull girder beyond which the hull structure collapses.

(2) Determination of hull girder ultimate bending moment capacity The ultimate bending moment capacities of a hull girder transverse section, in hogging and sagging conditions, are defined as the maximum values of the curve of bending moment M versus the curvature χ of the transverse section considered (M_{UH} for hogging condition and M_{US} for sagging condition, see **Fig 7.4.11**). The curvature χ is positive for hogging condition and negative for sagging condition.

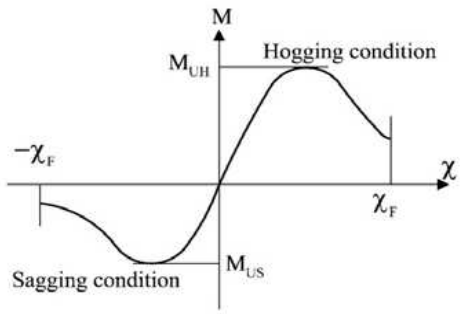


Fig 7.4.11 Bending moment M versus curvature *x*

The hull girder ultimate bending moment capacity M_U is to be calculated using the incremental-iterative method as given in **Annex 7-9, Appendix 3. 2** or using an alternative method as indicated in **Annex 7-9, Appendix 3. 3.**

4. Acceptance criteria

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

$$M \leq \frac{M_U}{\gamma_M \gamma_{DB}}$$

where:

M = Vertical bending moment (kNm), to be obtained as specified in **2**

M_U = Hull girder ultimate bending moment capacity (kNm), to be obtained as specified in **3**

γ_M = Partial safety factor for the hull girder ultimate bending capacity, covering material, geometric and strength prediction uncertainties, to be taken as 1.05

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

- For hogging condition: $\gamma_{DB} = 1.15$
- For sagging condition: $\gamma_{DB} = 1.0$

For cross sections where the double bottom breadth of the inner bottom is less than that at amidships or where the double bottom structure differs from that at amidships (e.g. engine room sections), the factor, γ_{DB} for hogging condition may be reduced based upon agreement with the Society.

207. Additional requirements for large container ships

1. General

The requirements in **2.** and **3.** are applicable to container ships with a breadth, B greater than 32.26 m.

2. Yielding and buckling assessment

Yielding and buckling assessments are to be carried out in accordance with the Rules of the Society, taking into consideration additional hull girder loads (wave torsion, wave horizontal bending and static cargo torque), as well as local loads. All in-plane stress components (i.e. bi-axial and shear stresses) induced by hull girder loads and local loads are to be considered.

3. Whipping

Hull girder ultimate strength assessment is to take into consideration the whipping contribution to the vertical bending moment according to the Society's procedures.

Section 3 Double Bottoms

301. General *(2018)*

1. The construction of double bottoms in holds which are exclusively loaded with containers is to be in accordance with the requirements of this Section. Except where required in this section, the requirements in **Pt.3 Ch.7** are to be applied.(*2019*)

2. Side girders or solid floors are to be arranged in the double bottoms under corner fittings. Otherwise, double bottoms are to be effectively strengthened so as to support container loads.

3. Where cargo hold is exclusively used for the stowage of containers, the requirements for ceiling and the increment of inner bottom plating under hatchways specified in **Pt 3, Ch 7, 501.** may not be applied.

4. The thickness of bottom shell plating and inner bottom plating in the double bottom spaces for void spaces, fuel oil tanks, etc. which do not contain sea water in service conditions may be reduced by 0.5mm from the thickness prescribed in this section.

5. For bottom longitudinals, sufficient consideration is to be given for fatigue strength.

302. Longitudinals 【See Guidance】

The section modulus of bottom or inner bottom longitudinals is not to be less than that obtained from the formula given in **Table 7.4.5,** respectively.

Table 7.4.5 Section modulus of longitudinals

Item	Section modulus (cm^3)
Bottom longitudinals	$Z_b = \frac{0.9\,CKSl^2}{24-15.0\,f_BK}\left\{d+0.013\,L'\left(\frac{2}{B}y+1\right)+h_1\right\}$
Inner bottom longitudinals	$Z_i = 100\,C_1\,C_2\,Shl^2 \quad (\geq 0.75\,Z_b)$

C = coefficient given in the following table.

Case	C
In case where no strut specified in **303.** is provided midway between floors	100
In case where a strut specified in **303.** is provided midway between floors	62.5

NOTE:
Where, however, the width of vertical stiffeners provided on floors and that of struts are large enough, the coefficient may be properly reduced.

h_1 : as given in (1) or (2)

(1) for $0.3L$ from the fore end ---- $\frac{3}{2}(17-20\,C_b')(1-x)$

C_b' : block coefficient (where C_b exceeds 0.85, C_b' is to be taken as 0.85)

(2) for eleswhere ---------- 0

$$x = \frac{X}{0.3\,L}$$

(X : distance(m) from the fore end for side shell plating. However, where X is less than that 0.1L, X is to be taken as 0.1L and where X exceeds 0.3L, X is to be taken as 0.3)

f_B : refer to Pt 3, Ch 1

L' : length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

y : horizontal distance (m) from the centre line of the ship to the longitudinals under consideration.

l : spacing of solid floors (m).

S : spacing of longitudinals (m).

$C_1 = \frac{K}{24-\alpha K}$ $\left(\geq \frac{K}{18}.\right.$ for $h_2,\ h_3,\ \left.\frac{K}{18}\right)$

$\alpha = 15.0\,f_B\left(1-\frac{z}{z_B}\right)$

z : vertical distance (m) from the top of the keel to the bottom of inner bottom plating

z_B : vertical distance (m) from the top of the keel midships to the horizontal neutral axis of the transverse section

C_2 : as determined from **Table 7.4.7**

h : the following h, h_2, h_3. however, where the double bottom space is void, h is to be taken as h_1

h_1: vertical distance (m) from the mid point between the bottom of inner bottom plating and the upper end of the overflow pipe

h_2: as obtained from the following formula

$h_2 = 0.85\,(h_1+\Delta h)$ (m)

$\Delta h = \frac{16}{L}(l_t-10)+0.25(b_t-10)$ (m)

l_t : tank length (m) (≥ 10 m)

b_t : tank breadth (m) (≥ 10 m)

h_3: value obtained by multiplying 0.7 by the vertical distance from the tank top plating to the point 2.0m above the top of the overflow pipe

303. Vertical struts

1. Vertical struts are to be of rolled sections other than flat bars or bulb plates and to be overlapped with the webs of bottom and inner bottom longitudinals.

2. The sectional area of the vertical struts is not to be less than that obtained from the following formula :

$$A = 1.8\,CKSbh \quad (\mathrm{cm}^2)$$

where:

S : spacing of longitudinals (m).

b : breadth of the area supported by the strut (m).

h : as obtained from the following formula (m).

$$h = \frac{d + 0.026L'}{2}$$

L' : as specified in **Table 7.4.5.**

C : coefficient obtained from the following formula. In no case is the value of coefficient to be less than 1.43.

$$C = \frac{1}{1 - 0.5\dfrac{l_s}{k\sqrt{K}}}$$

l_s : length of struts (m).

k : minimum radius of gyration of struts obtained from the following formula (cm).

$$k = \sqrt{\frac{I}{A}}$$

I : the least moment of inertia of the struts (cm^4).

A : sectional area of struts (cm^2).

304. Thickness of inner bottom plating

1. The thickness of inner bottom plating is not to be less than that obtained from the following formulae, whichever is the greater :

$$t_1 = \frac{CKB^2d}{d_0} + 1.5 \quad (\mathrm{mm})$$

$$t_2 = C'S\sqrt{hK} + 1.5 \quad (\mathrm{mm})$$

where :

d_0 : height of centre girder (m).

S : spacing of inner bottom longitudinals for longitudinal framing or frame spacing for transverse framing (m).

h : as given by the following formula.

$h = 1.13\,(d - 0.001d_0)$

C : coefficient obtained from **Table 3.7.7.** of **Pt 3**

C' : coefficient obtained from **Table 3.7.8.** of **Pt 3**

2. Notwithstanding the requirement 1., the thickness t of inner bottom plating is to be not less than obtained from the following formula.

$$t = 3.6\,CS\sqrt{hK} + 2.0 \quad (\mathrm{mm})$$

S : spacing of stiffeners (m)

h : as specified in **Table 7.4.5**

C : coefficient given in the following formula according to the stiffening system fo inner bottom plating used, however, for h_2 and h_3, C is to be taken as 1

(a) for transverse system

$$C = \frac{27.7}{\sqrt{767 - \alpha^2 K}}$$

α : as specified in **Table 7.4.5**

(b) for longitudinal system

$$C = \frac{3.72}{\sqrt{27.7 - \alpha K}} \quad (\ ) 1.0)$$

α : as specified in **Table 7.4.5**

3. The inner bottom plating with which the lower ends of corner fittings of containers are in contact is to be strengthened by means of doubling or by other appropriate means.

305. Thickness of bottom shell plating

1. The thickness t of bottom shell plating is not to be less than that obtained from the following formulae (1) and (2) or from the requirements in **Pt 3, Ch 7, sec 5 505.**, whichever is the greater. However, in the application of the requirements in **Pt 3, Ch 7, sec 5 505.**, the thickness need not apply to the requirement of **Pt 3, Ch 4, sec 3 304.**

(1) In ships with transverse framing, the thickness is not to be less than that obtained from the following formula:

$$t = C_1 C_2 S\sqrt{d + 0.0175\,L'\left(\frac{2}{B}y + 1\right) + h_1} + 1.5 \quad (\mathrm{mm})$$

where,

S : spacing (m) of transverse frames

L', y, h_1 : as specified in 302.

C_1 : coefficient given below

where $L \leq 230\,\mathrm{m}$, 1.0

where $L \leq 230\,\mathrm{m}$, 1.07

for intermediate value of L, C_1 is to be obtained by linear interpolation.

C_2 : coefficient given below

$$C_2 = \frac{91}{\sqrt{576 - (15.0 f_B x)^2}} \qquad x = \frac{X}{0.3L}$$

(X : distance (m) from the fore end for side shell plating afore the midship, or from the after end for side shell plating after the midships. However, where X is less than that $0.1L$, X is to be taken as $0.1L$ and where X is exceeds $0.3L$, X is to be taken as $0.3L$.

(2) In ships with longitudinal framing, the thickness of side shell plating is not to be less than that obtained from the following formula:

$$t = C_1 C_2 S\sqrt{d + 0.0175 L' (\frac{2}{B} y + 1) + h_1} + 1.5 \quad (\mathrm{mm})$$

where,

S : spacing (m) of longitudinal frames

C_2 : coefficient given below ($\geq 3.78\sqrt{K}$)

$$C_2 = 13\sqrt{\frac{K}{24 - 15.0 f_B K x}}$$

2. Notwithstanding the requirement in **-1**, the thickness t of bottom shell plating is to be not less than obtained from the following formula.

$$t = \sqrt{KL'} \quad (\mathrm{mm})$$

L' : length (m) of ship ($\leq 330\,\mathrm{m}$)

3. The breadth of plate keels is to be not less than obtained from the following formula.

$$b = 2L + 1000 \quad (\mathrm{mm})$$

The thickness of plate keel over whole length of the ship is not to be less than the thickness of the bottom shell for the midship part obtained from the requirements in 305.1 increased by 2.0 mm. This thickness, however, is not to be less than that of the adjacent bottom shell plating.

Section 4 Double Side Construction

401. General 【See Guidance】

1. Side construction in holds is to be double hull construction as far as practicable and is to be thoroughly stiffened by providing side transverse girders and side stringers within double hull.

2. The construction of double side in holds which are exclusively loaded with containers is to be in accordance with the requirements in the requirements of this Section. Except where required in this section, such construction is to be in accordance with the requirements in **Pt 3, Ch 14**. (*2019*)

3. Double side shell structures which are used as deep tanks are to be in accordance with the requirements in **Pt 3, Ch 15** unless otherwise specified in this Section. (*2018*)

4. In the application of the requirement in Pt 3, Ch 15, 104., the thickness of inner hull plating, interior of which are used as deep tank may be reduced by 1.0mm from the thickness prescribed in Table 3.15.1.

5. The thickness of side shell plating and inner hull plating in double side space for void space, fuel oil tanks, etc. which do not contain sea water I service conditions may be reduced by 0.5mm from the thickness prescribed in this section.

6. Side stringers are to be provided in a proper spacing considering the depth of holds. And, side transverse girders are to be provided at the location of solid floors in double bottoms.

7. The scantlings in case where the width of double side shell structures changes in bilge parts, are to be at the discretion of the Society.

8. The scantlings in case where the height from the load line to the strength deck is specially large, are to be at the discretion of the Society.

9. Where structures effectively supporting deck structures and side shell structures are provided in the midway of holds, the requirements in this section may be appropriately modified.

10. At the location where the longitudinal bulkheads and the inner bottom plating are combined, considerations are to be paid with regard to their structural arrangement so as not to cause stress concentration.

11. At the fore and aft ends of double side construction, sufficient considerations are to be paid to the continuity of construction and strength.

12. For side longitudinal, sufficient consideration is to be given for fatigue strength.

402. Side transverse and side stringers 【See Guidance】

The thickness of side transverse and side stringers is not to be less than that obtained from the following formula. However, where deemed necessary by the Society, the thickness of these members is to be determined in consideration of bending and shear strength.

$$t = 8.5\frac{S_2}{\sqrt{K}} + 1.5 \quad (\mathrm{mm})$$

where:

S_2 : S_1 or d_1, whichever is the smaller.

S_1 : spacing of the stiffeners provided in the direction of the depth of transverse on the web of transverse for side transverse or spacing of the stiffeners provided in the direction of the depth of stringer on the web of stringer for side stringer (m), respectively.

d_1 : depth of side transverse or side stringers (m). Where, however, the depth of webs is divided by providing stiffeners in the direction of the length of side transverse on the webs or of side stringer on the webs, d_1 may be taken as the divided depth, respectively.

403. Longitudinal bulkheads

The thickness of longitudinal bulkheads and the section modulus of longitudinal stiffeners in case where the double side structure is used as deep tanks, are not to be less than those obtained from the following formulae, respectively.

1. The thickness of longitudinal bulkheads is not to be less than that obtained from the following formula. However, the thickness of longitudinal bulkheads which are not in contact with sea water in service conditions may be reduced from the following requirements by 0.5 mm.

$$t = 3.6\,C_1 S\sqrt{Kh} + 2.0 \quad (\mathrm{mm})$$

where:

S : spacing of longitudinal stiffeners (m).

h : the following h, h_2, h_3. however, where the double bottom space is void, h is to be taken as h_1

h_1 : vertical distance (m) from the low edge of bulkhead plating under consideration to the mid-point between the point on the tank top and upper end of the overflow pipe

h_2 : as obtained from the following formula

$$h_2 = 0.85\,(h_1 + \Delta h) \quad (\mathrm{m})$$

$$\Delta h = \frac{16}{L}(l_t - 10) + 0.25(b_t - 10) \quad (\mathrm{m})$$

l_t : tank length (m) (≥ 10 m)

b_t : tank breadth (m) (≥ 10 m)

h_3 : value obtained by multiplying 0.7 by the vertical distance from low edge of bulkhead plating under consideration to the point 2.0m above the top of the overflow pipe

C_1 : coefficient obtained from **Table 7.4.6.** However, for h_2 and h_3, C_1 is to be taken as 1.

2. The section modulus of longitudinal stiffeners on longitudinal bulkheads is not to be less than that obtained from the following formula.

$$Z = 100\, C_1 C_2 S h l^2 \quad (\mathrm{cm}^3)$$

C_1 : $K/18$, the value C_1 for h_1, however, is to be as obtained from the following formula.

$$C_1 = \frac{K}{24 - \alpha K} \quad (\geq K/18)$$

α : coefficient determined according to **Table 7.4.6.**

C_2 : coefficient given in **Table 7.4.7.**

S : spacing of longitudinal stiffeners (m).

h : as specified in **1.** where "the lower edge of the bulkhead plating under consideration" is to be construed as "the stiffener under consideration"

l : span of girders (m).

404. Brackets

Brackets are to be provided on the upper and lower corners inside the double side structure, at every frame in case where transversely stiffened and at an appropriate spacing between side transverse girders in case where longitudinally stiffened.

Table 7.4.7 Coefficient C_2

One end of stiffener / The other end of stiffener	Connection with hard bracket	Connection with soft bracket	Supported by rule girder or lug connection
Connection with hard bracket	0.70	1.15	0.85
Connection with soft bracket	1.15	0.85	1.30
Supported by rule girder or lug connection	0.85	1.30	1.00

1. Connection with hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent members mentioned above. (See **Fig 3.14.2** (a))
2. Connection with soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (See **Fig 3.14.2** (b))

Table 7.4.6 Coefficients C_1

Framing	C_1
Transverse system	$\frac{27.7}{\sqrt{767-\alpha^2 K^2}}$
Longitudinal system	$\frac{3.72}{\sqrt{27.7-\alpha K}}$ but C_1 is not to be less than 1.0

α = as obtained from the following formulae, whichever is greater: However the value of α_1 or α_2 is not to be less than α_3

$$\alpha_1 = 15.0 f_D \left(\frac{y - y_B}{Y'} \right) \quad \text{where } z \geq z_B$$

$$\alpha_2 = 15.0 f_B \left(\frac{y_B - y}{y_B} \right) \quad \text{where } z < z_B$$

$$\alpha_3 = \frac{1}{9.81} \frac{M_H}{I_H} y_H \times 10^5$$

z : distance (m) from the top of keel to the lower edge of plating when the platings under consideration are under z_B and to the upper edge of plating when the platings under consideration are above z_B, respectively.

z_B : vertical distance from the top of keel to the horizontal neutral axis of transverse section (m).

f_B, f_D : as specified in **Pt 3, Ch 1**

Z : the greater of the values specified in **Pt 3, Ch 3, 203.** (5) (A) or (B), whichever is the greater

M_H: as given by te following formula

$$M_H = 0.45\, C_1 L^2 d\,(C_b + 0.05)\, C_H \quad (\text{kN m})$$

C_1: As given by following formula

$$10.75 - \left(\frac{300 - L_1}{100} \right)^{1.5} \quad L_1 \leq 300\,\text{m}$$

$$10.75 \quad 300 < L_1 \leq 350\,\text{m}$$

$$10.75 - \left(\frac{L_1 - 300}{150} \right)^{1.5} \quad 350\,\text{m} < L_1$$

L_1 : Length(m) specified in **Pt 3, Ch 1, 102.** or 0.97 times the length of ship on the designed maximum load line, whichever smaller

C_H : Coefficient, as given in following table, based on the ration of L to x, where x is the distance (m) from the aft end of L to the section under consideration. Intermediate values are to be determined by interpolation.

x/L	0.0	0.4	0.7	1.0
C_H	0.0	1.0	1.0	0.0

I_H : Moment of inertia(cm^4) of the cross section about the vertical neutral axis of the transverse section under consideration

y_H : Horizontal distance(m)from the vertical neutral axis to the evaluation point

405. Side Shell Plating

1. The side shell plating below the strength deck is to be in accordance with the requirements in **405.** Unless otherwise specified in **405,** such plating is also to be in accordance with **Pt 3, Ch 4.**

2. The thickness t of side shell plating other than the sheer strake specified **Pt 3, Ch 4, 303.** is to be as required in the following (1) and (2) in addition to the requirements in **Pt 3, Ch 4, 301.** and **302.**

(1) In ships with transverse framing, the thickness of side shell plating is not to be less than that obtained from the following formula:

$$t = C_1 C_2 S\sqrt{d - z' + 0.05L' + h_1} + 1.5 \quad (\mathrm{mm})$$

where,

S : spacing(m) of transverse frame

L', C_1 and h_1 : as specified in **305. 1**

z' : vertical distance(m) from the top of the keel to the lower edge of side shell plating under consideration. (However, in case of $z > d$, z is to be taken as d.)

C_2 : Coefficient given below:

$$C_2 = 91\sqrt{\frac{K}{576 - \alpha^2 K^2 x^2}}$$

α : As given in following formula, whichever is greater

$$\alpha_1 = 15.0 f_B\left(1 - \frac{z}{z_B}\right) \qquad \alpha_2 = \frac{1}{9.81}\frac{M_H}{I_H} y_H \times 10^5$$

z : Vertical distance (m) from the top of the keel to the lower edge of the side shell plating under consideration.

z_B, f_B : As specified in **Table 7.4.5**

M_H, I_H, y_H : As specified in **Table 7.4.6**

x : As specified in **305. 1** (1)

(2) In ships with longitudinal framing, the thickness of side shell plating is not to be less than that obtained from the following formula:

$$t = C_1 C_2 S\sqrt{d - z' + 0.05L' + h_1} + 1.5 \quad (\mathrm{mm})$$

where,

S : Spacing(m) of longitudinal frame

z', L', C_1 and h_1 : as specified in (1)

C_2 : Coefficient given below:

$$C_2 = 13\sqrt{\frac{K}{24 - \alpha K x}} \qquad (\geq 3.78\sqrt{K})$$

α and x : as specified in (1)

3. The t Notwithstanding the requirement in **Par 2**, the thickness of t of the side shell plating below the strength deck is to be not less than obtained from the formula in **305. 2.**

406. Side Longitudinals

1. The section modulus Z of the side longitudinals below the freeboard is not to be less than that obtained from the following formula (1) and (2), whichever is greater.

(1) $Z = 90\,CShl^2$

where,

S : Spacing(m) of longitudinal frame

l : Spacing(m) of girders

h : Vertical distance(m) from the side longitudinal concerned to a point $d + 0.038L' + 0.75h_1$ above the top of keel

h_1, L' : as specified in 202.1

C_2 : Coefficient given below:

$$C = \frac{K}{24 - \alpha K} \quad (\geq \frac{K}{18})$$

α = As obtained from the following formulae, whichever is greater:

$$\alpha_1 = 15.0 f_D \left(\frac{z - z_B}{Z'} \right) \quad \text{where} \quad z_B < z$$

$$\alpha_2 = 15.0 f_B \left(1 - \frac{z}{z_B} \right) \quad \text{where} \quad z \leq z_B$$

$$\alpha_3 = \frac{1}{9.81} \frac{M_H}{I_H} y_H \times 10^5$$

z : Vertical distance(m) from the top of keel to the longitudinal under consideration

z_B : As specified in **Table 7.4.5**

f_B , f_D , Z', M_H, I_H and y_H : As specified in **Table 7.4.6**

(2) $Z = 2.9 K \sqrt{L'} S l^2 \quad (\text{cm}^3)$

S, l, L' : As specified in (1)

2. The section modulus Z of side longitudinal where the interior of double side structure is used as deep tank are to be in accordance with the requirements in **403. 2**.

Section 5 Transverse Bulkheads

501. Construction

1. Transverse bulkheads are to be constructed so as to be sufficiently supported at the location of deck. In case where the width of bulkhead is specially large, the upper parts of transverse bulkheads are to be appropriately strengthened by providing box-shaped structures or by other means.

2. The scantlings of bulkheads and stiffeners are to comply with the requirements in **Pt 3, Ch 14, Sec 3.**

502. Partial bulkheads

Where non-watertight partial bulkheads are provided in cargo holds, the construction and scantlings are to be made to have sufficient strength and rigidity, considering the size of cargo hold, the depth of bulkheads, etc.

Section 6 Deck Construction

601. Construction 【See Guidance】

1. The thickness of deck plating is to comply with the requirement in **Pt 3, Ch 5, Sec 3.**

2. The scantlings of decks inside the line of deck openings are to be appropriately strengthened in consideration of bending in the plane of deck.

602. Cross ties

1. Where the length of hatchway is large in comparison with the width of hatchway, cross ties are to be provided in the hatchway opening with suitable spacing.

2. Where structures effectively supporting the loads from the side and deck of ship are not provided at the location of cross ties in the holds, special considerations are to be paid to the scantlings of cross ties.

603. Continuity of thickness of deck plating

Consideration is to be paid to the continuity in the thickness of deck plating. Especially, the abrupt change between the thickness inside and outside the line of deck openings is to be avoided.

Section 7 Breakwater

701. Breakwater

1. Arrangement

(1) If cargo is intended to be carried on deck forward of 0,85L, a breakwater or an equivalent protecting structure (e.g. whaleback or turtle deck) is to be installed.

2. Dimensions of the breakwater

(1) The recommended height of the breakwater is as following.

$$h_w = 0.8\,(b c_1 - z)\ \text{(m)} \quad (\ h_{w\_\min} = 0.6(b c_1 - z)\ )$$

where

z : the vertical distance (m) between the summer load line and the bottom line of the breakwater.

$$b = 1.0 + 2.75\left(\frac{\frac{x}{L} - 0.45}{C_B + 0.2}\right)^2 \qquad (0.6 \leqq C_B \leqq 0.8)$$

x : distance (m) from aft end of L to breakwater

c_1 : Wave coefficient

$$10.75 - \left(\frac{300 - L}{100}\right)^{1.5} \qquad \text{where } L \leq 300 \text{ m}$$

$$10.75 \qquad \text{where } 300 < L \leq 350 \text{ m}$$

$$10.75 - \left(\frac{L - 300}{150}\right)^{1.5} \qquad \text{where } 350 < L \leq 500 \text{ m}$$

The average height of whalebacks or turtle decks has to be determined analogously according to **Fig 7.4.12**.

(2) The breakwater has to be at least as broad as the width of the area behind the breakwater, intended for carrying deck cargo.

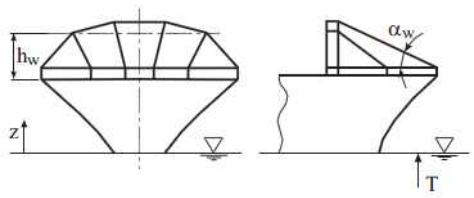


Fig 7.4.12 Whaleback

3. Cutouts

Cutouts in the webs of primary supporting members of the breakwater are to be reduced to their necessary minimum. Free edges of the cutouts are to be reinforced by stiffeners. If cutouts in the plating are provided to reduce the load on the breakwater, the area of single cutouts should not exceed 0.2m^2 and the sum of the cutout areas not 3 % of the overall area of the breakwater plating.

4. Loads *(2017)*

(1) The loads for dimensioning are to be determined according to following formula.

$p_A = n\ (bc_1 - z)\quad (\mathrm{kN/m^2})$

p_A is not to be less than following values

$25 + \frac{L}{10}$ where $L \leq 250$ m

50 where $L > 250$ m

$n = 10 + L/20$ where $L \leq 300$ m, if L is greater than 300 m, L is to be taken as 300 m

$c = \sin\alpha_w$ (α_w is to be determined on centre line)

5. Plate thickness and stiffeners

(1) The plate thickness has to be determined according to following formula.

$t = t' + t_k \quad (\mathrm{mm})$

$t' = 0.9\,s\,\sqrt{p_A K}$

$t_k = 1.5$ where $t' \leqq 10$ mm

$t_k = 0.1t'/\sqrt{K} + 0.5$ where $t' > 10$ mm

$t_{\min} = (5.0 + \frac{L}{100})\sqrt{K}$ (mm) (where $L \leq 300$ m, if L is greater than 300 m, L is to be taken as 300 m)

(2) The section modulus of stiffeners are to be calculated according to following formula. Stiffeners are to be connected on both ends to the structural members supporting them.

$Z = 0.35\,s\,l^2\,p_A\,K(\mathrm{cm^3})$

l : span (m) of stiffeners

s : spacing (m) of stiffeners

(3) For whalebacks with an inclining angle w of less than 20° the scantlings of plates and stiffeners are to be in accordance with the dicsretion of the Society.

6. Primary supporting members

For primary supporting members of the structure, a stress analysis has to be carried out. The permissible equivalent stress, σ_v is $230/K$ ($\mathrm{kN/m^2}$).

7. Proof of buckling strength

Structural members' buckling strength has to be proved according to **Pt 11, Ch 6, sec 3.**

Section 8 Tug Pushing Area

801. Strengthenings for harbour and tug manoeuvres

1. In those zones of the side shell which may be exposed to concentrated loads due to harbour manoeuvres the plate thickness is not to be less than required by **Par 2.** These zones are mainly the plates in way of the ship's fore and aft shoulder and in addition amidships. The exact locations where the tugs shall push are to be defined in the building specification. They are to be identified in the shell expansion plan. The length of the strengthened areas shall not be less than approximately 5 m. The height of the strengthened areas shall extend from about 0,5 m above ballast draught to about 4,0 m above scantling draught. (Where the side shell thickness so determined exceeds the thickness required by this section, it is recommended to specially mark these areas.)

2. The plate thickness in the strengthened areas is to be determined by the following formula:

$t = 0.65\ \sqrt{P_{fl} K} + 1.5\ (\mathrm{mm})$

P_{fl}: local design impact force (kN)

= $D/100$ (200 kN ≤ P_{fl} ≦700 kN)

D : displacement of the ship (t)

3. In the strengthened areas the section modulus of side longitudinals is not to be less than: 3

$$Z = 0.35\, P_{fl}\, l\, K \quad (\mathrm{cm}^3)$$

l : unsupported span (m) of longitudinal

4. Tween decks, transverse bulkheads, stringer and transverse walls are to be investigated for sufficient buckling strength against loads acting in the ship's transverse direction.

Section 9 Strength at Large Flare Location

901. Shell plating 【See Guidance】

With regard to the shell plating at a location where flare is specially large, sufficient consideration is to be paid to the reinforcement against panting impact, etc. at bow.

902. Frames 【See Guidance】

The frames fitted in the bow flare position considered to endure large wave impact pressure, are to be properly strengthened taking care of the effectiveness of their end connections.

903. Girders 【See Guidance】

The girders fitted in the bow flare position considered to endure large wave impact pressure, are to be properly strengthened taking care of the effectiveness of their end connections.

Section 10 Freight Container Securing Arrangements

1001. Cell guide

1. The cell guides supporting containers are to be constructed so as to effectively transmit the loads to double bottom structure, side construction and transverse bulkheads.

2. The strength of cell guide is to be sufficient for the loads from the bottom and side of ship and the loads due to container loads.

1002. Freight container securing systems 【See Guidance】

1. For freight container securing systems plans showing materials, arrangement and scantling, etc. may be submitted for approval of the Society. Where container securing fittings are applied for part container only, this requirements may be suitably applied.

2. ecuring devices specified in **Par 1** are to be approved in accordance with **Annex 7-2 「Guidance for the Container Securing Arrangements」** prior to installation on board the ship. *(2021)*

3. Container supporting structures are to be of rolled steel for hull structural specified in **Pt 2, Ch 1, 301.** However, other materials may be used if approved by the Society. *(2020)*

4. In order to assigned the additional special feature "CSAP" (Cargo Safety Approach), the provisions of **Annex 7-11 「Guidelines for Providing Safe Working Conditions for Retaining Containers on Deck」** should be satisfied. *(2021)*

Section 11 Welding

1101. Application

1. Fillet welding is to be applied to longitudinals with a web plate thickness over 40 mm and up to 80 mm, which are used for the strength deck or for side shell plating and longitudinal bulkheads that extend upwards from a position 0.25 D below the strength deck.
2. Where longitudinals with a web plate thickness over 80 mm are used, the kind and size of the weldings are to be at the discretion of the Society.

1102. Fillet Welding

1. Fillet welding is to be continuous.
2. The size of fillet is to be not less than 8 mm. ⚓

CHAPTER 5
SHIPS CARRYING LIQUEFIED GASES IN BULK

(Separate Publication)

CHAPTER 6
SHIPS CARRYING DANGEROUS CHEMICALS IN BULK

(Separate Publication)

CHAPTER 7 CAR FERRIES AND ROLL-ON/ROLL-OFF SHIPS

Section 1 General

101. Application

1. This Chapter applies to seagoing roll-on/roll-off cargo ships specially designed and constructed for the carriage of vehicles, and cargo in pallet form or in containers, and loaded and unloaded by wheeled vehicles.
2. The hull structures and equipments of ships that are intended for restricted service and carriage of vehicles through the bow door, inner door, side door or ramp formed the hull structures (hereinafter refered to as vehicle doors) is to in accordance with the requirement in **Annex 7-3 「Guidance for Car Ferries」.** *(2021)*
3. The scantlings and arrangements are to be as required by **Pt 3** except as otherwise specified in this Chapter.

102. Construction and arrangement

1. The requirements provide for a basic structural configuration of a multideck hull which includes a double bottom, and in some cases wing tanks up to the lowest deck. Special consideration is to be given to roll on-roll off cargo ships and ferries intended to be operated only in certain areas or conditions which have been agreed by the Society.
2. Where bulkheads are omitted in accordance with **Pt 3, Ch 9,** a system of partial bulkheads, web frames and deck transverses should be fitted to provide equivalent transverse strength.
3. Longitudinal framing is to be adopted at the strength deck and at the bottom, but special consideration will be given to proposals for transverse framing in these regions.

103. Submission of plans and documentations

In addition to plans and documentations required by **Pt 3, Ch 1, Sec 3,** the following details are to be submitted:

(1) The intended service areas required for ships designed to operate within specified geographical limits.
(2) Bow or stern ramps
(3) Bow, stern and side doors
(4) Movable decks, if fitted, including stowing arrangements for portable components.

Section 2 Longitudinal Strength

201. General

Longitudinal strength calculations are to be made in accordance with the requirements given in **Pt 3, Ch 3.**

Section 3 Deck Structure

301. Application 【See Guidance】

The arrangements and scantlings of vehicle decks for the carriage of cars, trucks, etc., are be in accordance with the discretion of the Society.

302. Securing arrangements

Details of the connections to the hull of vehicle securing arrangements are to be submitted for approval.

Section 4 Electrical Equipment of Automobile Carriers

401. General

The requirements in this Section apply to the electrical equipment installed in the cargo holds and the compartments adjacent thereto of automobile carriers.

402. Electrical equipment

1. Electrical equipment in cargo hold

(1) In principle no portable electrical appliance are to be located in the cargo holds. Where it is inevitable to locate the appliances in the holds, they are subject to the approval of the Society.

(2) All electrical circuits terminating in the cargo holds are to be provided with multipole linked isolating switches situated outside the cargo holds, and accessible only to authorized personnel. Provision is to be made for isolation and for locking in the "off" position of the means of control of such circuits. However, this requirement does not apply in respect of safety devices such as fire, smoke or gas detector.

(3) In addition to the requirements in this section, the requirements in **Pt 8, Ch 13, Sec 2.** of the Rules are to be complied with.

2. Electrical equipment in the compartment adjacent to cargo holds

For the electrical equipment in the compartments adjacent to the cargo holds and having an opening such as nongastight door, hatch, scuttle and the like in their bulkheads and decks, the requirements in **Par 1** are generally to be applied. ⚓

CHAPTER 8 OFFSHORE SUPPLY SHIPS

Section 1 General

101. Application

1. The construction and equipment of ships intended to be registered and classed as "Offshore Supply Ship" are to be in accordance with the requirements in this Chapter, where "Offshore Supply Ship" means a ship designed and constructed for the carriage of specialized stores and cargoes to mobile offshore units and other offshore installations, and also to "Offshore Tug and Supply Ship" which in addition to the above perform the duties of a tug.
2. The scantlings and arrangements are to be as required by **Pt 3,** except as otherwise specified in this Chapter.
3. Attention is drawn to the need for masters to be able to assess the stability of their ships quickly and accurately in all service conditions.

102. Submission of plans and documentations

In addition to plans and documentations required by **Pt 3, Ch 1, Sec 3,** the followings are to be submitted.
(1) Separate or independent cargo tanks
(2) Cargo tank foundations and securing arrangements
(3) Towing arrangements, including supports and foundations of towing winches
(4) Supports and foundations for anchor handling and laying arrangements for anchors carried as cargo.
(5) Arrangements for the stowage of deck cargoes (cargo containment) and details of any associated racks or other similar structures and their supports and foundations.
(6) Movable decks including the stowing arrangements for portable components
(7) Freeing arrangements

Section 2 Longitudinal Strength

201. General

Longitudinal strength calculations for an offshore supply ship or an offshore tug/supply ship are to comply with the relevant requirements of **Pt 3, Ch 3.**

Section 3 Shell Plating

301. Shell plating

1. The thickness of side shell is to be that required by **Pt 3, Ch 4,** but is in no case to be less than 9 mm.
2. Efficient fenders are to be fitted, with adequate support behind them, in exposed areas.
3. Shell in way of stern rollers immediately adjacent to high duty bollards and in other high load areas is to be suitably reinforced.

Section 4 Deck Plating

401. Weather decks

1. Where cargo is to be carried on weather decks, the scantlings are to be suitable for the specified loadings, but in no case is a head less than 3.5 m to be used. Additional local increases in scantlings may be required where specialized cargoes are likely to induce concentrated loads.
2. The thickness of deck plating is to be not less than that obtained from the following formula.

$$t = 0.025L + 6 \quad (\mathrm{mm})$$

402. Cargo containment

1. Means are to be provided to enable deck cargoes to be adequately secured and protected. In general, suitable inner bulwarks, rails, bins or storage racks of substantial construction are to be provided and properly secured to adequately strengthened parts of the hull structure .
2. Properly designed locking equipment or efficient means of lashing containers are to be fitted where appropriate.
3. Small hatches (including escape hatches), valve controls, ventilators, air pipes, etc., are to be situated clear of the cargo containment areas.

Section 5 Framing

501. Transverse framing

The section moduli of the main and tween deck frames are to be 25 percent greater than those required by **Pt 3, Ch 8, Sec 4.** Frames are not to be scalloped.

Section 6 Superstructures and Deckhouses

601. Scantlings

The scantlings of deckhouses situated on the forecastle deck and above are to comply with the requirements of **Table 7.8.1.**

Table 7.8.1 Thickness of plating and section modulus of bulkhead stiffeners etc.

Position	Thickness of plating t (mm)	Modulus of stiffeners Z (cm^3)	Depth of stiffeners d (mm)
Fronts	The greater of t = $0.012S$ or 8.0	$Z = 0.034\,S\,l^2$	$d \geq 100$
Sides	The greater of t = $0.01S$ or 6.5	$Z = 0.027\,S\,l^2$	$d \geq 75$
Aft ends	The greater of t = $0.008S$ or 6.5	$Z = 0.021\,S\,l^2$	$d \geq 65$
S = stiffener spacing (mm) l = effective length of stiffeners (m)			
NOTE : The ends of stiffeners are to be connected on all tiers.			

Section 7 Watertight Bulkhead Doors

701. Watertight doors

Watertight doors are to be efficiently constructed and fitted in accordance with **Pt 3, Ch 14, Sec 4.**

Section 8 Engine Exhaust Outlets

801. Location

Engine exhaust outlets are to be located as high as is practicable above the deck and are to be fitted with spark arresters. ⚓

CHAPTER 9 TUGS

Section 1 General

101. Application

1. The construction and equipment of ships intended to be registered as "Tug" are to be in accordance with the requirements in this Chapter. The construction and equipment of ships intended to be registered as "Offshore Tug/Supply Ships" are to be in accordance with the requirements of **Ch 8.**
2. The scantlings and arrangements are to be as required by **Pt 3** except as otherwise specifiedin this Chapter. The draught d used for the determination of scantlings is to be not less than $0.85D$.

Section 2 Longitudinal Strength

201. General

Longitudinal strength calculations are to be made in accordance with the requirements given in **Pt 3, Ch 3.**

Section 3 Single Bottoms

301. Floors

Single bottom floors are to be in accordance with the requirements of **Pt 3, Ch 6.**

Section 4 Panting and Strengthening of Bottom Forward

401. Panting region reinforcement

The arrangements to resist panting required by **Pt 3, Ch 9** do not apply to tugs less than 46 m in length. In tugs 46 m or more in length, addition stiffening is also to be fitted in the tween decks throughout the panting region.

402. Strengthening of bottom forward

The requirements for strengthening of bottom forward detailed in **Pt 3, Ch 7, Sec 8** do not apply to tugs.

Section 5 Machinery Casings

501. Escape hatches

Any emergency exit from the machinery room to the deck is to be capable of being used at extreme angles of heel, and should be positioned as high as possible above the waterline and on or near the ship's centerline. Covers to escape hatches are to have hinges arranged athwartships. Coaming heights are to be at least 600 mm above the upper surface of the deck.

502. Exposed casings

Exposed machinery casings are to be not less in height than 900 mm above the upper surface of the deck. Stiffeners to exposed casings are to be connected to the deck or carried through.

Section 6 Towing Arrangements

601. Towing hooks

1. Towing hooks or equivalent should normally be 5 to 10 percent of the ship's length abaft amidships, but in no circumstances should they be sited forward of the longitudinal center of gravity of the tug in any anticipated condition of loading. In addition, the towing hook should be located as low as practicable in order to minimize heeling moments arising in normal working conditions.

2. Towing hooks are to have reliable release slip arrangement which facilitate towline release regardless of the angle of heel. It is recommended that release units should also be operable from the bridge. The arrangements should be tested to the surveyor s satisfaction. The breaking strength of the hook or its equivalent should generally be 50 percent in excess of that of the towline.

Section 7 Fenders

701. Ship's side fenders

An efficient fender is to be fitted to the ship's side at deck level extending all fore and aft.

Section 8 Towing Winch Emergency Release Systems *(2021)*

801. General

1. Scope

(1) This Section defines minimum safety standards for winch emergency release systems provided on towing winches that are used on towing ships within close quarters, ports or terminals, including those ships normally not intended for towing operation in transverse direction.

(2) This Section is not intended to cover towing winches on board ships used solely for long distance ocean towage, anchor handling or similar offshore activities.

2. Purpose

The purpose of this section is to provide requirements to prevent the capsize of a tug when in the act of towage as a result of the towline force acting transversely to the tug (in beam direction) as a consequence of an unexpected event (could be loss of propulsion/steering or otherwise), whereby the resulting couple generated by offset and opposing transverse forces (towline force is opposed by thrust or hull resistance force) causes the tug to heel and, ultimately, to capsize. This capsize may be referred to as "girting", "girthing", "girding" or "tripping". See **Fig 1** which shows the forces acting during towage operations.

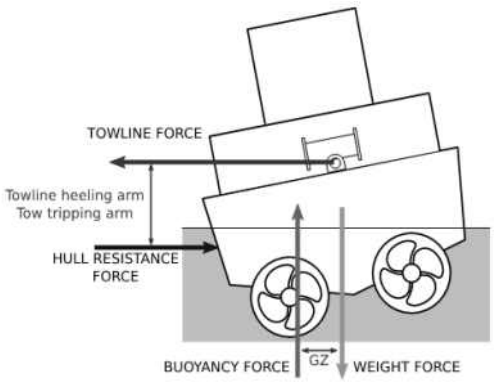


Figure 1 Force during towing

3. Definitions

(1) Emergency release system refers to the mechanism and associated control arrangements that are used to release the load on the towline in a controlled manner under both normal and black out conditions.

(2) Maximum design load is the maximum load that can be held by the winch as defined by the manufacturer (the manufacturer's rating).

(3) Fleet angle is the angle between the applied load (towline force) and the towline as it is wound onto the winch drum, see **Fig 2**.

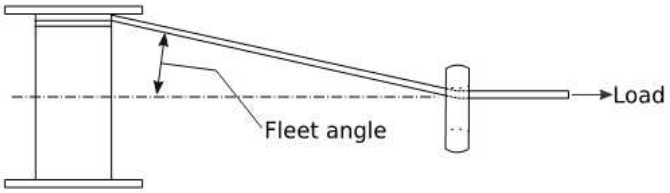


Figure 2 Towline 'fleet angle'

802. General requirements

1. The in-board end of the towline is to be attached to the winch drum with a weak link or similar arrangement that is designed to release the towline at low load.

2. All towing winches are to be fitted with an emergency release system.

803. Emergency release system requirements

1. Performance requirements

(1) The emergency release system is to operate across the full range of towline load, fleet angle and ship heel angle under all normal and reasonably foreseeable abnormal conditions (these may include, but are not limited to, the following: vessel electrical failure, variable towline load (for example due to heavy weather), etc.).

(2) The emergency release system shall be capable of operating with towline loads up to at least 100 % of the maximum design load.

(3) The emergency release system is to function as quickly as is reasonably practicable and within a maximum of three seconds after activation.

(4) The emergency release system is to allow the winch drum to rotate and the towline to pay out in a controlled manner such that, when the emergency release system is activated, there is sufficient resistance to rotation to avoid uncontrolled unwinding of the towline from the drum. Spinning (free, uncontrolled rotation) of the winch drum is to be avoided, as this could cause the towline to get stuck and disable the release function of the winch.

(5) Once the emergency release is activated, the towline load required to rotate the winch drum is to be no greater than:

(A) the lesser of 5 tonnes or 5 % of the maximum design load when two layers of towline are on the drum, or

(B) 15 % of the maximum design load where it is demonstrated that this resistance to rotation does not exceed 25 % of the force that will result in listing sufficient for the immersion of the lowest unprotected opening.

(6) Emergency release of the towline is to be possible in the event of a blackout. For this purpose, where additional sources of energy are required, such sources are to comply with (7).

(7) The sources of energy required by (6) are to be sufficient to achieve the most onerous of the following conditions (as applicable):

(A) sufficient for at least three attempts to release the towline (i.e. three activations of the emergency release system). Where the system provides energy for more than one winch it is to be sufficient for three activations of the most demanding winch connected to it.

(B) Where the winch design is such that the drum release mechanism requires continuous application of power (e.g. where the brake is applied by spring tension and released using hydraulic or pneumatic power) sufficient power is to be provided to operate the emergency re-

lease system (e.g. hold the brake open and allow release of the towline) in the event of a blackout for a minimum of five minutes. This may be reduced to the time required for the full length of the towline to feed off the winch drum at the load specified in (5) if this is less than five minutes.

2. Operational requirements

(1) Emergency release operation must be possible from the bridge and from the winch control station on deck. The winch control station on deck is to be in a safe location. A position in close proximity to the winch is not regarded as "safe location", unless it is documented that the position is at least protected against towline break or winch failure.
(2) The emergency release control is to be located close to an emergency stop button for winch operation, if provided, and shall be clearly identifiable, clearly visible, easily accessible and positioned to allow safe operability.
(3) The emergency release function is to take priority over any emergency stop function. Activation of the winch emergency stop from any location is not to inhibit operation of the emergency release system from any location.
(4) Emergency release system control buttons are to require positive action to cancel, the positive action may be made at a different control position from the one where the emergency release was activated. It must always be possible to cancel the emergency release from the bridge regardless of the activation location and without manual intervention on the working deck.
(5) Controls for emergency use are to be protected against accidental use.
(6) Indications are to be provided on the bridge for all power supply and/or pressure levels related to the normal operation of the emergency release system. Alarms are to activate automatically if any level falls outside of the limits within which the emergency release system is fully operational.
(7) Wherever practicable, control of the emergency release system is to be provided by a hard-wired system, fully independent of programmable electronic systems.
(8) Computer based systems that operate or may affect the control of emergency release systems are to meet the requirements for Category III systems of **KR Rules Pt 6, Sec 4.**
(9) Components critical for the safe operation of the emergency release system are to be identified by the manufacturer.

804. Test requirements

1. General

(1) All testing defined within this paragraph is to be witnessed by a Classification Society surveyor.
(2) For each emergency release system or type thereof, the performance requirements of **803. 1** are to be verified either at the manufacturer's works or as part of the commissioning of the towing winch when it is installed on board. Where verification solely through testing is impracticable (e.g. due to health and safety), testing may be combined with inspection, analysis or demonstration in agreement with the Society.
(3) The performance capabilities, as well as instructions for operation, of the emergency release system are to be documented by the manufacturer and made available on board the ship on which the winch has been installed.
(4) Instructions for surveys of the emergency release system are to be documented by the manufacturer, agreed by the Society and made available on board the ship on which the winch has been installed.
(5) Where necessary for conducting the annual and special surveys of the winch, adequately sized strong points are to be provided on deck.

2. Installation trials

(1) The full functionality of the emergency release system is to be tested as part of the shipboard commissioning trials to the satisfaction of the surveyor. Testing may be conducted either during a bollard pull test or by applying the towline load against a strong point on the deck of the tug that is certified to the appropriate load.
(2) Where the performance of the winch in accordance with **803. 1** has previously been verified, the load applied for the installation trials is to be at least the lesser of 30 % of the maximum design load or 80 % of vessel bollard pull. ⚓

CHAPTER 10 DOUBLE HULL TANKER

Section 1 General

101. Application 【See Guidance】

1. The requirements in this Chapter apply to double hull oil tankers which were contracted for construction after 1 April 2006, excluding the vessels which should be applied **Pt 13** (Common Structural Rules for Bulk Carriers and Oil Tankers).
2. The constructions and equipments of ships of 90 m and above in length which are framed for tankers with machinery aft having one or more longitudinal bulkheads and single decks with double bottom or with double hull structures, intended to be registered and classed as "tanker" and intended to carry crude oil, petroleum products having a vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 ℃ or other similar liquid cargoes in bulk are to be in accordance with the requirements in this Chapter.
3. In tankers intended to carry liquid cargoes other than crude oil and petroleum products, having the vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 ℃ and having no hazard as poisonous, corrosive, etc. and moreover less inflammablity than that of crude oil and petroleum products, the structural arrangements and scantlings are to be to the satisfaction of the Society, having regarded to the properties of the cargoes to be carried.
4. In case where the construction differs from that specified in **Par 1** and the requirements in this Chapter are considered to be not applicable, matters are to be determined as deemed appropriate by the Society.
5. As regards matters not specifically provided for in this Chapter, the general requirements for the construction and equipment of steel ships given in the relevant **Pts** are to be applied.
6. In addition to the requirements specified in **Par 5,** the relevant requirements in **Ch 1, Secs I0** to **11** and **Pt 8, Ch 2, Sec 4.** are to be applied to ships specified in **Par 2.**
7. Notwithstanding the each requirement, the application of below requirements may be exempted in accordance with the requirement of flag state.
   (1) **102. 2.** and **7.**
   (2) **904.**

102. Location and separation of spaces 【See Guidance】

1. In cargo oil spaces, the standard arrangement of bulkheads is to be such that the interval between longitudinal bulkheads or transverse bulkheads does not exceed $1.2\sqrt{L}$ (m).
2. Cofferdams are to be provided in accordance with the following (1) to (3):
   (1) Cofferdams of air-tight construction and not to be less than 600 mm in width access are to be provided at fore and aft terminations of cargo oil spaces and the space between cargo space and accommodation space. Where, however, for oil tankers intended to carry cargo oil having a flash point above 60 ℃ this requirements may be suitably modified.
   (2) Cofferdams specified in (1) may be used as pump rooms.
   (3) Fuel oil or ballast water tanks may be concurrently used as the cofferdams to be provided between cargo oil tanks and fuel oil or ballast tanks, subject to the approval by the Society.
3. Passageways leading to cargo areas are to be provided in accordance with the following (1) to (4):
   (1) Access to cofferdams, ballast tanks, cargo oil tanks and any other spaces in the cargo area are to be direct from the open deck and such as to ensure their complete inspection. Access to double bottom spaces may be through a cargo pump room, pump room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.
   (2) For access through horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a selfcontained air breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the spaces. The minimum clear opening is not to be less than 600 mm × 600 mm.

(3) For Access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening should be not less than 600 mm × 800 mm at a height of not more than 600 mm from the bottom shell plating unless grating or other foot-holds are provided.
(4) For tankers with a deadweight tonnage of less than 5000 tons, smaller dimension of minimum clear opening specified in (2) and (3) may be approved by the Society in special circumstances, if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Society.

4. Air-tight bulkheads

All areas, where cargo oil pumps and cargo oil piping are provided, are to be segregated by an air-tight bulkhead from areas where stoves, boilers, propelling machinery, electric installations other than those of explosion-proof type in accordance with the requirements in **Pt 6, Ch 1, Sec 9** where source of ignition is normally present. Where, however, for oil tankers carrying cargo oil having a flash point above 60℃, the requirements may be suitably modified.

5. Ventilations

Ventilation inlets and outlets are to be arranged so as to minimize the possibilities of vapours of cargoes being admitted to an enclosed space containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard. Especially, opening of ventilation for machinery spaces are to be situated as far afterwards apart from the cargo spaces as practicable.

6. Ullage openings, sighting ports and tank cleaning opening are not to be arranged in enclosed spaces.

7. Openings in superstructure and deckhouse

The arrangement of openings on the boundaries of superstructures and deckhouse are to be such as to minimize the possibility of accumulation of vapours of cargoes. Due consideration in this regard is to be given for the openings in superstructures and deckhouse when the ship is equipped with cargo piping to load or unload at the stern. The scuttles to the poop front or other similar walls are to be of fixed type.

8. Pipe duct in double bottom

Pipe ducts in the double bottom shall comply with the following requirements :
(1) They should not communicate with the engine room.
(2) Provision shall be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exits fitted with a watertight closure may lead to the cargo pump room.
(3) In the duct, provision shall be made for adequate mechanical ventilation.
(4) For ships to which the convention applies, refer to **SOLAS 1974(as amended) Regulation II-2/4.5.2.4.**

103. Minimum thickness

1. The thickness of structural members in cargo oil tanks and deep tanks such as bulkhead plating, floors, transverse girders including struts and their end brackets is not to be less than the value determined from **Table 7.10.1** according to the Length of Ship. **【See Guidance】**

2. The thickness of structural members other than **Par 1** in cargo oil tanks and deep tanks is not to be less than 7 mm.

Table 7.10.1 Minimum thickness

L (m)													
	and over		105	120	135	150	165	180	195	225	275	325	375
	and under	105	120	135	150	165	180	195	225	275	325	375	
Thickness(mm)		8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5

104. Direct strength calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct strength calculation defined in **Pt 3, Ch 1, 206.** Notwithstanding the results of direct strength calculation, where, however, this is not to be applied to the minimum thickness specified in **103.** and the special requirements for corrosion specified in **605.** to **607.**

105. Symbols

The definition of symbols used in this Chapter otherwise specified, are to be in accordance with following :

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

l = span of stiffeners, longitudinals, frames, transverses or girders (m).

S = spacing of stiffeners, longitudinals, frames, transverses or girders (m).

C_1 = coefficients determined according to values of L as specified below :

C_1 = 1.0 where L is 230 m and under,

1.07 where L is 400 m and above.

For intermediate values of L, C_1 are to be obtained by linear interpolation.

C_1' = coefficients determined according to values of L as specified below :

C_1' = 1.0 where L is 230 m and under,

1.2 where L is 400 m and above.

For intermediate values of L, C_1' are to be obtained by linear interpolation .

f_D and f_B = section modulus ratios are as following formulae, f_B, however, is not to be less than 0.85 or $0.0015L$ + 0.5, whichever is the lesser.

$$f_D = \frac{Z_{DMreq}}{Z_{Dact}} \qquad f_B = \frac{Z_{BMreq}}{Z_{Bact}}$$

Z_{DMreq} and Z_{BMreq} = section modulus at the deck and bottom of transverse sections of the hull determined to the requirements in **Ch 3, 201.** respectively, when mild steel material symbol *A, B, D* and *E* specified in **Pt 2, Ch 1, 301. Par 1** is used (cm^3).

Z_{Dact} and Z_{Bact} = actual section modulus at the deck and bottom of transverse sections of the hull respectively. (cm^3)

α = either α_1 or α_2 according to value of y. However, value of α is not to be less than α_3.

$$\alpha_1 = 15.0\, f_D \left(\frac{y - y_B}{Y'} \right) \qquad \text{for} \quad y \geq y_B$$

$$\alpha_2 = 15.0\, f_B \left(\frac{y_B - y}{y_B} \right) \qquad \text{for} \quad y < y_B$$

$$\alpha_3 = \beta \left(\frac{B - 2b}{B} \right)$$

y = distance from the top of keel to the lower edge of plating when the platings under consideration are under y_B, to the upper edge of plating when the platings under consideration are above y_B and to the longitudinals stiffener under consideration for longitudinal stiffener, respectively (m).

y_B = distance from the top of keel to the horizontal neutral axis of transverse section amidship (m).

Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5), (a) or (b).

β = coefficient determined according to the values of L as specified below: For intermediate values of L, the value of b is to be determined by linear interpolation:

β = 6.0 when L is 230 m and under,
10.5 when L is 400 m and above.

a = $\sqrt{K}$ when high tensile steels are used for not less than 80 % of side shell platings at the transverse section amidship and 1.0 for other parts.

b = horizontal distance from the side shell plating to the longitudinal bulkhead plating under consideration (m).

106. Stability Instrument

The requirements of stability Instrument comply with **Ch 1, Sec. 1, 110.**

Section 2 Bulkhead Plating

201. Bulkhead plating in cargo oil tanks and deep tanks *(2020)* 【See Guidance】

1. The thickness of bulkhead plating is not to be less than the greatest of the values obtained from the following formula.

$$t_1 = C_1 C_2 S\sqrt{h} + 2.5 \quad (\mathrm{mm})$$

where:

h = water head of h_1, h_2 or h_3 is obtained from **Table 7.10.2.** When the tank use the flow-through ballast water exchange operations method, h_4 and h_5 are to be additionally considered. ***(2020)***

C_2 = coefficients is obtained from **Table 7.10.3.**

C_1 and S = as specified in **105.**

2. In determining the thickness of longitudinal bulkhead plating, coefficient C_2 for h_1 may be gradually reduced for the parts forward and aftward the midship part, and it may be taken as $3.6\sqrt{K}$ in calculations at $0.1L$ from fore end and aft end.

202. Swash Bulkheads 【See Guidance】

1. Stiffeners and girders of swash bulkhead are to be of sufficient strength considering the size of tanks and opening ratios.

2. The thickness of swash bulkhead plating is not to be less than that obtained from the following formula :

$$t = 0.3S\sqrt{K(L+150)} + 2.5 \quad (\mathrm{mm})$$

where:

S = as specified in **105.**

3. In determining the thickness of swash bulkhead plating, sufficient consideration is to be given for buckling.

203. Trunks

The thickness of trunk top and side plating are to be determined applying the requirements in **201.** in addition to the requirements in **Pt 3, Ch 5.**

Table 7.10.2 Water head h *(2020)*

	Cargo oil tanks	Deep tanks
h_1	Vertical distance from the lower edge of the bulkhead plating under consideration to the top of hatchway. For side shell plating, a water head corresponding to the minimum draught amidship d_{min} (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be d_{min}, value at point d_{min} above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation.	Vertical distance from the lower edge of the bulkhead plating under consideration to the mid-point between the point on tank top and the upper end of the overflow pipe. For side shell plating, a water head corresponding to the minimum draught amidship d_{min} (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be d_{min}, value at point d_{min} above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation
h_2	As obtained from the following formula $h_2 = 0.85(h_1 + \Delta h)$ where: Δh = additional water head given by the following formula; For L-type, U-type etc. of tanks, Δh is to be determined as deemed appropriate by the Society $\Delta h = \frac{16}{L}(l_t - 10) + 0.25(b_t - 10)$ l_t = tank length (m), 10, when less than 10 m. b_t = tank breadth (m), 10, when less than 10 m	
h_3	$h_3 = 0.3\sqrt{L}$ (m)	Value (m) obtained by multiplying 0.7 by vertical distance from the lower edge of the bulkhead plating under consideration to the point 2.0 m above the top of overflow pipe..
h_4	-	Vertical distance from the lower edge of the bulkhead plating under consideration to the top of the overflow pipe (or air pipe) to the point where the overpressure is added (m). (Overpressure : due to sustained liquid flow through overflow pipe in case of overfilling or filling during flow through ballast water exchange. It is to be defined by the designer, but not to be less than 2.5.)
h_5	-	$0.85(h_4 + \Delta h)$ Δh : as specified in h_2

Table 7.10.3 Coefficient C_2

	longitudinal bulkhead of longitudinal framing	longitudinal bulkhead of transverse framing
For h_1	$C_2 = 13.4\sqrt{\frac{K}{27.7 - \alpha K}}$	$C_2 = 100\sqrt{\frac{K}{767 - \alpha^2 K^2}}$
	minimum : $3.6\sqrt{K}$	
For h_2 or h_3 and for transverse bulkhead	$C_2 = 3.6\sqrt{K}$	

Section 3 Longitudinals and Stiffeners

301. Longitudinals

1. The section modulus of bottom longitudinals is not to be less than the value obtained from the formula in **Table 7.10.4.**

2. The section modulus of side longitudinals including bilge longitudinals is not to be less than the value obtained from the formula in **Table 7.10.4.** The section modulus, however, need not exceed that of bottom longitudinals specified in **Table 7.10.4,** but is not to be less than that obtained from the following formula :

$$Z = 2.9 K \sqrt{L} S l^2 \quad (\mathrm{cm}^3)$$

where:
S and l = as specified in **105.**

Table 7.10.4 Section modulus of bottom and side longitudinal

longitudinals	section modulus (cm^3)
Bottom longitudinals	$Z = 100 C_1 C_2 S h l^2$
Side longitudinals including bilge longitudinals	

h = distance from the longitudinals under consideration to the h' (m).
C_2 and h' = as given in following table

	h'	C_2
Bottom longitudinals	$h' = d + 0.026 L'$	$C_2 = \dfrac{K}{24 - 15.0 f_B K}$
Side longitudinals including bilge longitudinals	$h' = d + 0.038 L'$	$C_2 = \dfrac{K}{24 - \alpha K}$

C_1, S, l, L', α and f_B = as specified in **105.**

3. For the parts forward and aftward of midship part, the scantlings of longitudinals may be gradually reduced and at $0.1L$ from fore end and aft end they may be reduced by 15 % of the value obtained from the requirements in **Pars 1** and **2.** In no case, however, are the scantlings of longitudinals to be less than those required in **Pars 1** and **2** for the part between a point $0.15L$ from the fore end and the collision bulkhead.

4. For side longitudinals, sufficient consideration is to be given for fatigue strength. **【See Guidance】**

5. In addition to the requirements in **Pars 1** to **4,** the beams or longitudinals on deck or side shell consisting of deep tanks should comply with the requirements in **302.**

302. Bulkhead stiffeners in cargo oil tanks and deep tanks *(2020)*

1. Section modulus of stiffeners is not to be less than that obtained from the following formula :

$$Z = 125 C_1 C_2 C_3 S h l^2 \quad (\mathrm{cm}^3)$$

Where:
h = water head h_1, h_2 or h_3 as specified in **Table 7.10.2.** Where, however, "the lower edge of the bulkhead plating under consideration" is to be construed as "the mid-point of the stiff-

ener under consideration" for vertical stiffeners and as "the stiffener under consideration" for horizontal stiffeners. And "side shell plating" is to be construed as "stiffener attached to side shell plating". When the tank use the flow-through ballast water exchange operations method, h_4 and h_5 as specified in **201.** are to be additionally considered. ***(2020)***

C_2 = value obtained from following formula. The value C_2 for h_1, however, is to be as obtained from the formula in **Table 7.10.5.**

$$C_2 = \frac{K}{18}$$

C_3 = as determined from **Table 7.10.6** according to the fixity condition of stiffener ends;
C_1, S and l = as specified in **105.**

Table 7.10.5 Coefficient C_2

Bulkhead and framing systems	C_2
Longitudinal bulkhead of longitudinal framing system	$C_2 = \frac{K}{24-\alpha K}$ minimum $C_2 = \frac{K}{18}$
Longitudinal bulkhead of transverse framing system, transverse bulkhead	$C_2 = \frac{K}{18}$
α = as specified in **105.**	

Table 7.10.6 Coefficient C_3

One end of stiffener / The other end of stiffener	Connection be hard bracket	Connection be soft bracket	Supported by rule girder or lug connection	Snip
Connection be hard bracket	0.70	1.15	0.85	1.30
Connection be soft bracket	1.15	0.85	1.30	1.15
Supported by rule girder or lug connection	0.85	1.30	1.00	1.50
Snip	1.30	1.15	1.50	1.50

1. Connection by hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent members mentioned above. (See **Fig 3.14.2** (a))
2. Connection by soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (See **Fig 3.14.2** (b))

2. For the parts forward and aftward of midship part in determining the section modulus of stiffeners attached to longitudinal bulkhead of longitudinal framing systems, coefficient C_2 for h_1 may be gradually reduced, and at the end parts C_2 may be as K/18.

303. Buckling strength

1. Buckling strength of longitudinal frames, beams and stiffeners is to be in accordance with the requirements (1) to (3) below. In case where the Society specially considers necessary according to the materials, scantling, geometries and the point of arrangement of these structural members, detailed assessment may be required.

(1) Longitudinals beams, side longitudinals attached to sheer strakes and longitudinal stiffeners attached to the longitudinal bulkhead within $0.1D$ from the strength deck are to have a slenderness ratio not exceeding 60 at the midship part as far as practicable.

(2) As for flat bars used for longitudinal beams, frames and stiffeners, the ratio of depth to thickness is not to exceed 15.

(3) The full width of face plate of longitudinal beams, frames and stiffeners is not to be less than that obtained from the following formula:

$$b = 2.2\sqrt{d_0 l} \quad (\mathrm{mm})$$

where :

d_0 = depth of web of longitudinal beam, frame or stiffener (mm).

l = as specified in **105.**

2. In case where assembled members, special shape steels or flanged plates are used for frames, beams or stiffeners in cargo oil tanks and deep tanks whose scantlings are specified only in terms of section modulus, the thickness of web is intended to be greater than the required level due to reasons other than strength, it may be suitably modified.

$$t = 0.015 k_0 d_0 + 2.5 \quad (\mathrm{mm})$$

where:

d_0 = depth of web (mm).

k_0 = coefficient according to the location of stiffeners as given **Table 7.10.7.**

Table 7.10.7 Coefficient k_0

Locations	k_0
Bottom longitudinals located not more than $0.25D$ above top of keel	$k_0 = \sqrt{0.25\left(3f_B + \frac{1}{K}\right)}$
Deck longitudinals located not less than $0.25D$ below deck	$k_0 = \sqrt{0.25\left(3f_D + \frac{1}{K}\right)}$
Other structural members	$k_0 = \sqrt{0.25\left(3 + \frac{1}{K}\right)}$

Section 4 Girders

401. General

1. The double bottom and double side hull structures and arrangements and scantlings of girders in cargo oil spaces are to be determined based upon direct strength calculations.

2. Notwithstanding the requirement in **Par 1,** when approved by the Society, the scantlings of these girders may be determined in accordance with the requirements in **403.** to **407.** provided that the arrangements of girders in the double bottom, double side hull and cargo oil tank at cargo oil spaces are determined referring to the structural types shown in following (1) to (5) as the standard: **【See Guidance】**

(1) The height of double bottom at cargo oil spaces is not to be less than $B/20$ (m).
(2) The width of double side hull is not to be less than $D/9$ (m).
(3) In double bottoms at cargo oil spaces, girders are to be provided at a spacing not exceeding 0.9 $\sqrt{l_t}$ (m) and floors are to be provided at a spacing not exceeding 0.55 $\sqrt{B}$ (m) or 0.75 $\sqrt{D}$ (m), whichever is smaller. l_t is the length of a cargo hold (m).
(4) In double side hull, stringer are to be provided at a spacing not exceeding 1.1 $\sqrt{l_t}$ (m).
(5) Transverse in double side hull and girders in cargo oil tanks and deep tanks are to be provided at positions on floors in double bottoms.

402. Direct strength calculation of girders 【See Guidance】

The structural models, loads, allowable stress levels, etc. for determining the arrangement of girders and scantling based upon direct strength calculation are to as deemed appropriate by the Society.

403. Scantlings of girders and floors in double bottom 【See Guidance】

The scantling of girders and floors in double bottom are to be as deemed appropriate by the Society.

404. Scantlings of stringers and transverse in double side hull 【See Guidance】

The scantling of stringers and transverse in double side hull are to be as deemed appropriate by the Society.

405. Girders and transverse in cargo oil tanks and deep tanks *(2020)* 【See Guidance】

1. The section modulus of girders is not to be less than that obtained from the following formula:

$$Z = 7.13\, C_1' k^2 K S h l^2 \quad (\mathrm{cm}^3)$$

Where:

h = waterhead h_1, h_2 or h_3 as specified in **Table 7.10.2.** whichever is the greatest. Where, however, "from the lower edge of the bulkhead plating under consideration" is to be construed as "from the mid-point of S" for horizontal girders, and as "from the mid-point of l" for vertical girders in applying the value of h. When the ship use the flow-through ballast water exchange operations method, h_4 and h_5 as specified in **201.** are to be additionally considered. ***(2020)***

k = correction factor for brackets, and to as obtained from the following formula:

$$k = 1 - \frac{0.65(b_1 + b_2)}{l}$$

b_1 and b_2 = arm length of brackets at respective ends to be girders and transverses (m).

C_1', S and l = as specified in **105.**

2. The moment of inertia of girders is not to be less than that obtained from the following formula. However, in no case is the depth of girders to be less than 2.5 times the depth of slots.

$$I = 30hl^4 \quad (\mathrm{cm}^4)$$

Where:

h and l = as specified in **Par 1.**

3. The thickness of girders is not to be less than the greatest of the following t_1, t_2 or t_3 :

$$t_1 = 41.7\frac{C_1' C_2 KShl}{d_1} + 2.5 \quad (\mathrm{mm})$$

$$t_2 = 0.174\sqrt[3]{\frac{C_1' C_2 Shl S_1^2}{d_1}} + 2.5 \quad (\mathrm{mm})$$

$$t_3 = 0.01S_1 + 2.5 \quad (\mathrm{mm})$$

Where:

h = as specified in **Par 1.**

S_1 = spacing of stiffeners of girders or the depth of girders, whichever is the smaller (mm).

d_1 = depth of the girder under consideration (mm) subtracting the depth of openings.

C_2 = coefficient as obtained from the following formula. In no case is it to be less than 0.5 :

Vertical girder : $C_2 = \left| 1 - \frac{2x}{l} \right|$

Horizontal girder : $C_2 = \left| 1 + \frac{0.2\,l}{h} - \left(2 + \frac{l}{h}\right)\frac{x}{l} + \frac{l}{h}\left(\frac{x}{l}\right)^2 \right|$

Where:

x = distance from the end of l to the sectional area under consideration(m), and from the lower end for vertical girders.

C_1', S and l = as specified in **105.**

4. Where, the stiffeners are provided within the effective width, they may be included in the effective steel plates for calculating actual moment of inertia of girders and section modulus.

5. The thickness of webs at the root of struts for girders and transverse in case where struts are provided, is not to be less than that obtained from following formula. Where slots are provided in bs at the root of struts, they are to be covered effectively with collar plates.

$$t = 16S_1\sqrt{\frac{C_1' S b_s h_s}{A}} \quad (\mathrm{mm})$$

Where:

b_s = width supported by struts (m).

h_s = distance from mid-point of b_s to the point of $d + 0.038L'$ above top of keel (m).

S_1 = spacing of stiffeners provided depthwise on the web plates of transverses at the portion where cross ties are connected (m).

C_1' and S = as specified in **105.**

A = as specified in **Ch 1, 403.** (1).

6. The thickness of face plates forming a girder is to be greater than the thickness of web, and the total width is not to be less than that obtained from the following formula :

$$b = 2.7\sqrt{d_0 l'}$$

where:

d_0 = depth of girder (mm)

l' = distance between supporting points of girders (m). Where, however, if effective tripping brackets are provided, they may be regarded as supporting points.

406. Girders of ships without double side hull

1. In addition to the requirements in **405.**, depth of side transverse d_0 and section modulus of transverse Z are not to be less than those obtained from the following formula :

$$d_0 = 150\,l \quad (\mathrm{mm})$$
$$Z = 8.7k^2KSh\,l^2 \quad (\mathrm{cm}^3)$$

Where:

h = distance from mid-point of l to the point $d + 0.038L'$ above top of keel (m)

k, l and S = as specified in **405.1.**

2. The scantlings of deck transverses are to as given in (1) and (2) below :

(1) Section modulus of deck transverse of a ship without trunks is not to be less than that obtained from the following formula :

$$Z = 3k^2KS\sqrt{L}\,l^2 \quad (\mathrm{cm}^3)$$

Where:

k, l and S = as specified in **405.1.**

(2) For ships with trunks, the construction of providing continuous deck transverses across the trunk is to be considered as the standard. In this case, the depth of deck transverses that can be regarded as those supported by trunks may be $0.03B$.

3. For transverses provided on the centreline bulkhead, the section modulus Z and depth d_0 of deck transverses are to be less than those obtained from the following formula :

$$d_0 = 120\,l \quad (\mathrm{mm})$$
$$Z = 7.0k^2KSh\,l^2 \quad (\mathrm{cm}^3)$$

Where:

k, l, S and h = as specified in **Par 1.**

407. Stiffeners attached to girders in cargo oil tanks and deep tanks

The thickness of flat bar stiffeners and tripping brackets provided on girders and transverses is not to be less than that obtained from the following formula. However, it needs not exceed the thickness of webs of the girder to which they are provided.

$$t = 0.5\sqrt{L} + 2.5 \quad (\mathrm{mm})$$

408. Cross ties

1. Cross ties in ships having two or more rows of longitudinal bulkheads, where they are effectively connected with longitudinal bulkhead transverses in cargo oil tanks are to be in accordance with this requirements.
2. The sectional area of cross ties interconnecting longitudinal bulkhead transverses in cargo oil tanks is not to be less than that obtained from the following formula :

$$A = C_1' C_2 K S b_s h \quad (\mathrm{cm}^2)$$

Where:

b_s = as specified in **405. 5.**

h = h_s where cross ties are provided in wing cargo oil tanks, vertical distance from mid-point of b_s to top of hatchways of adjacent cargo oil tanks where struts are provided in centre cargo oil tanks (m).

C_2 = coefficient obtained from the following formula, in no case, however, is to be less than 1.1

$$C_2 = \frac{0.77}{1 - 0.5\frac{l}{k}}$$

l = length of cross ties between the inner surface of longitudinal bulkhead transverses (m).

k = as given below : $k = \sqrt{\frac{I}{A}}$

I = moment of inertia of cross ties (cm^4).

A = sectional area of cross ties (cm^2)

C_1' and S = as specified in **105.**

Section 5 Structural Details

501. General 【See Guidance】

1. The principal structural members are to be arranged so that continuity of strength can be secured throughout the cargo area. In forward and afterward parts of the cargo area, the structures are to be effectively strengthened so that continuity of strength is not impaired sharply.
2. For the principal structural members, sufficient consideration is to be given for fixity at ends, supporting and stiffening systems against out-of-plane deflections and the construction is to minimize local stress concentration.

502. Frames and stiffeners

Longitudinal beams, frames and stiffeners are to be of continuous structures, or to be connected securely so that their sectional area at ends can be properly maintained providing sufficient resistance against bending moments.

503. Girders and cross ties 【See Guidance】

1. Girders provided within the same are to be arranged to avoid sharp changes in strength and rigidity, and brackets in suitable size are to be provided at the ends of girders, and bracket toes are to be sufficiently rounded.

2. In case where the depth of longitudinal girders is large, stiffeners are to be arranged in parallel with face plates.
3. Brackets are to be provided at the ends of cross ties to connect to transverses or girders.
4. Transverses and vertical webs are to be provided with tripping at the junctions with cross ties.
5. Where breadth of face plates forming cross ties exceeds 150 mm on one side of the web, stiffeners are to be provided at proper interval to support the face plates as well.
6. Tripping brackets are to be provided on the web plate transverses at the inner edge of end brackets and at the connecting part of cross ties, etc. and also at the proper interval in order to support transverses effectively. In case where the width of face plates of each girder exceeds 180 mm on one side, the tripping brackets shown above are to support face plates as well.
7. Webs for the upper and lower end brackets of side transverses and longitudinal bulkhead transverses and areas in the vicinity of their inner ends and those in the vicinity of the roots of cross ties are to be stiffened specially with closer spacing.

Section 6 Special Requirements for Corrosion

601. Thickness of shell plating

1. The thickness of shell plating forming casing cargo oil tanks planned to carry ballast water in ships without double side hull is not to be less than a thickness added with 0.5 mm to that obtained from the formula given in **Pt 3, Ch 4.**
2. The thickness of shell plating when applying the requirements of this Chapter may be reduced with 0.5 mm from the thickness obtained from the formula given in **201.**

602. Thickness of deck plating

1. The thickness of freeboard deck plating when applying the requirements of this Chapter may be reduced with 0.5 mm from the thickness obtained from the formula given in **201.**
2. The thickness of the freeboard deck plating in spaces carrying cargo oil when applying the requirements in **Pt 3, Ch 5,** is not to be less than a thickness added with 0.5 mm to that obtained from the formula given in **Pt 3, Ch 5.**

603. Thickness of tank top plating

The thickness of tank top plating in cargo oil tanks and deep tanks is not to be less than the thickness corresponding to that obtained from the formula given in **201.** added by 1.0 mm. Such an addition, however, is not required for the thickness of inner bottom plating.

604. Section moduli of longitudinal beams, frames and stiffeners

1. The section modulus of longitudinal beams provided on deck plating forming casing cargo oil tanks is not to be less than 1.1 times that calculated according to the requirements of **Pt 3, Ch 10.**
2. The section modulus of frames and stiffeners provided on shell plating and bulkheads forming cargo oil tanks planned to carry also ballast water, except the tank to carry ballast water only in heavy weather conditions, is not to be less than 1.1 times that calculated in accordance with the requirements **301.** and **302.**

605. Thickness of plate members in ballast tanks adjacent to cargo oil tanks

1. The thickness of bulkhead plating at the boundaries between ballast tanks and cargo oil tanks is not to be less than the thickness specified in **103.** added by 1.0 mm.

2. In case where the adjacent cargo oil tanks are equipped with heating systems, the thickness of bulkhead plating at the boundaries between ballast tanks and cargo oil tanks is not to be less than the thickness determined from **Par 1** added by 1.0 mm.

606. Thickness of deck plating in cargo oil tanks

The thickness of deck plating in cargo oil tanks is not to be less than the thickness specified in **103.** added by 1.0 mm.

607. Thickness of inner bottom plating in cargo oil tanks 【See Guidance】

1. The thickness of inner bottom plating of cargo oil tanks is to be sufficient considering the effects of pitting corrosion.
2. The thickness of inner bottom plating in the vicinity of suction bell mouths in cargo oil tanks, and the thickness of suction well, when provide, are not to be less than the thickness obtained by the requirements in **201.** for the appropriate area of application added by 2.0 mm.

Section 7 Special Requirements for Forward Wing Tanks

701. Application

For tankers of not less than 200 m, in length, the structural members in wing tanks which become empty in full loaded condition for spaces from a point $0.15L$ from the fore end to the collision bulkhead are to comply with the requirements in this Section as well as the requirements in each previous Articles concerned.

702. Side longitudinal

1. The section modulus of side longitudinals is not to be less than that obtained from the following formula :

$$Z = 9 C_1 K S h l^2 \quad (\mathrm{cm}^3)$$

Where :

h = distance (m) from the longitudinals under consideration to the point $0.7d + 0.05L$ above top of keel. Where, however, in no case is h to be less than obtained from the following formula (m);

$$h_{\min} = 0.2\sqrt{L} + 0.03L$$

C_1, S and l = as specified in **105.**

2. In case where side longitudinals are connected to transverses by brackets, the section modulus may be determined by multiplying the value obtained from the following formula by the value obtained from the formula specified in **Par 1 :**

$$(1 - C)^2$$

Where:

C = as obtained from the following formulae:

where brackets are provided at both ends $C = \dfrac{b_1 + b_2 - 0.3}{l}$

where a bracket is provided at one end $C = \dfrac{b - 0.15}{l}$

b_1, b_2 and b = length of bracket arms along longitudinals (m). Where, however, in case where the value of C is negative, C = 0 (See **Fig 7.10.1**)

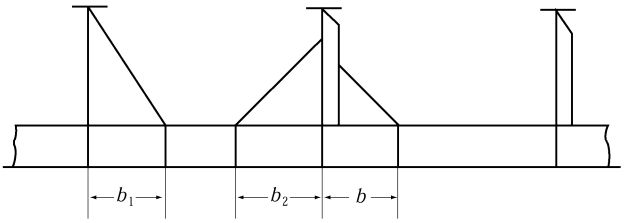


Fig 7.10.1 Measurement of b, b_1 and b_2

703. Reinforcement of bottom forward

The requirements of bottom forward are to comply with the requirements in **Pt 3, Ch 4, 404.** and **Pt 3, Ch 7, Sec 8.**

Section 8 Special Requirements for Tankers with Mid-deck

801. Application 【See Guidance】

1. The structural members of tankers having mid-deck penetrating longitudinally through the cargo areas are to comply with the requirements in **Sec 1** to **Sec 7.**
2. The scantling of structural members in cargo oil tanks below mid-deck are be as deemed appropriate by the Society.

Section 9 Special Requirements for Hatchways and Permanent Gangway

901. Ships having unusually large freeboard

Relaxation from the requirements specified hereunder will be considered to ships having an unusally large freeboard.

902. Hatchways to cargo oil tanks 【See Guidance】 *(2018)*

1. The thickness of coaming plates is not to be less than 10 mm. Where the length and coaming height of a hatchway exceed 1.25 m and 760 mm respectively, vertical stiffeners are to be provided to the side or end coamings and the upper edge of coamings is to be suitably stiffened.
2. Hatchway covers are to be steel or other approved materials. The construction of steel hatchway covers is to comply with the following requirements. The construction of hatchway covers of materials other than steel is to be in accordance with the discretion of the Society.
   (1) The thickness of cover plates is not to be less than 12 mm.
   (2) Where the area of a hatchway exceeds 1 m^2 but dose not exceed 2.5 m^2, cover plates are to be stiffened by flat bars of 100 mm in depth spaced not more than 610 mm apart. Where, however, the cover plates are 15 mm or more in thickness, the stiffeners may be dispensed with.
   (3) Where the area of a hatchway exceeds 2.5 m^2, cover plates are to be stiffened by flat bars of 125 mm in depth spaced not more than 610 mm apart.
   (4) Covers are to be secured oiltight by fastenings spaced not more than 457 mm apart in circular hatchways or 380 mm apart and not more than 230 mm far from the corners in rectangular hatchways.

903. Hatchway to spaces other than for cargo oil tanks *(2021)*

In exposed positions on the freeboard and forecastle decks or on the tops of expansion trunks, hatchways serving spaces other than cargo oil tanks, ballast tank, fuel oil tank and other tanks are to be provided with steel weathertight covers having scantlings complying with the requirements in **Pt 4, Ch 2, Sec 3.**

904. Permanent gangway and passageway 【See Guidance】

1. A fore and aft permanent gangway complying with the requirements of **Pt 4, Ch 5, 503.** is to be provided at the level of the superstructure deck between the midship bridge or deckhouse and poop or aft deckhouse, or equivalent means of access is to be provided to carry out the purpose of gangway, such as passage below deck. Elsewhere and in ships without midship bridge or deckhouse, arrangements to the satisfaction of the Society are to be provided to safeguard the crew in reaching all parts used in the necessary work of the ship.
2. Safe and satisfactory access from the gangway level is to be available between crew accommodations and machinery space or between separated crew accommodations.
3. Where superstructures are connected by trunks, open rails are to be provided for the whole length of the exposed parts of the freeboard deck.

Section 10 Welding

1001. Application

The welding in tankers is to be accordance with the requirements given in **1002.** in addition to **Pt 3, Ch 1, Sec 5.**

1002. Fillet welding 【See Guidance】

1. The application of fillet welding to structural members within the cargo area is to as given in **Table 7.10.9.**
2. The leg length of fillet welds in areas given in (1) and (2) below is to be at least 0.7 times the plate thickness as specified in the requirements in this Chapter.
   (1) Fillet welding at the connected parts between the outermost girders in the double bottom and floors.
   (2) Fillet welding at the connected parts between the lowermost stringers in the double side hull and transverses.

Table 7.10.9 Application of Fillet Welding

Column	Item		Application	kind of weld
1	Girders and Transverses	Web plates	Shell, deck, longitudinal bulkhead or inner bottom plating	F1
2			Web plates	F1
3			Face plates	F2
4		Slots in web plates	Web plates of longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F2
5		Tripping brackets and stiffeners provided on web plates	Web plates	F3
6			Longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F1
7	Longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads		Shell, deck or longitudinal bulkhead plating	F3
8	Cross ties		Members forming cross ties (web plates to face plates)	F3
9			Face plates of transverses or girders	F1

Note:
Where the radius at the toe of end brackets is small, it is recommended that F1 be used for appropriate length at the toe of bracket.

2021

Guidance Relating to the Rules for the Classification of Steel Ships

Part 7
Ships of Special Service

GA-07A-E

KR

APPLICATION OF THE GUIDANCE RELATING TO THE RULES

This "Guidance Relating to the Rules for the Classification of Steel Ships" (hereafter called as the Guidance Relating to the Rules) is prepared with the intent of giving details as to the treatment of the various provisions for items required the unified interpretations and items not specified in the Rules, and the requirements specified in the Guidance Relating to the Rules are to be applied, in principle, in addition to the various provisions in the Rules.

As to any technical modifications which can be regarded as equivalent to any requirements in the Guidance Relating to the Rules, their flexible application will be properly considered.

APPLICATION OF PART 7 "SHIPS OF SPECIAL SERVICE"

1. Unless expressly specified otherwise, the requirements in these Guidance apply to ships for which contracts for construction are signed on or after 1 July 2021.
2. The amendments to the Guidance for 2020 edition and their effective date are as follows;

Effective Date : 1 January 2021

Annex 7-8 Instruction for Use of Extremely Thick Steel in Container Ships
- totally amended.

Effective Date : 1 July 2021

CHAPTER 1 OIL TANKERS

Section 10 Piping Systems and Venting Systems for Oil Tankers
- 1001. 2 has been deleted.

CHAPTER 3 BULK CARRIERS

Section 1 General
- 101. 2 has been deleted.

Section 14 Water Level Detection & Alarms and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships
- 1401. has been deleted.

CHAPTER 4 CONTAINERS

Section 1 General
- 103. has been deleted.

CHAPTER 7 CAR FERRIES AND ROLL-ON/ROLL-OFF SHIPS

Section 1 General
- 101. has been deleted.

CHAPTER 9 TUGS
- Chapter 9 has been deleted.

CHAPTER 10 DOUBLE HULL TANKER

Section 4 Girders

- 401. has been amended.

Annex 7-2 Guidance for the Container Securing Arrangements

- 7.(1)(F) has been amended.
- Fig 3 has been amended.
- 8.(1)(A) and (4)(C) have been amended.

Annex 7-3 Guidance for Car Ferries

- 6. (2) and (3) have been amended.

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CHAPTER 1 OIL TANKERS

Section 1 General

101. Application 【See Rule】

1. The prescription in this Guidance principally apply to oil tankers having two longitudinal bulkheads and constructed on the longitudinal framing system, intended for carriage of oils of flash point not exceeding 60°C. Unless otherwise specially noted, the prescriptions in other parts apply for matters common to both cargo ships and tankers.

2. Proposal of novel construction type

In the event that a novel construction type is proposed, scantlings are to be determined by carrying out comparative calculations with the standard structural model conforming to the requirements of the Rules. Submission of data covering the results of model experiments or real ship experiments may be requested by the Society as necessary.

3. Ships carrying liquid cargoes other than crude oil and petroleum products

In application of **101. 5** of the Rules, ships intended to carry liquid cargoes having a vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 ℃ other than crude oil and petroleum products, are to be in accordance with the followings.

(1) The scantlings of structural members of the cargo oil tank part of tankers carrying liquid cargoes of a specific gravity ρ exceeding 1.0 are to be of the values obtained by the following two procedures, whichever is greater:

(A) To calculate for all of the structural members in accordance with the relevant requirements of the Rules

(B) To calculate for respective structural members in accordance with the following prescription:

(a) The scantlings of members attached to shell plating, cross ties and members attached to longitudinal bulkhead which are connected with members attached to shell plating through cross ties are to be determined by the formulae in the Rules, in which h is to be replaced by h_0 shown in **Fig 7.1.1.**

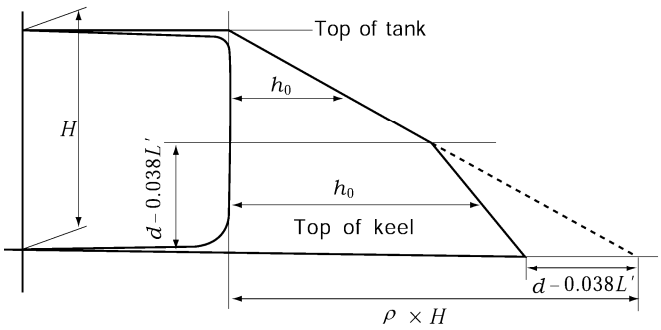


Fig 7.1.1. Measurement of h_0

(b) The scantlings of bulkhead plating, members attached to bulkheads and cross ties are to be determined on the assumption that the tank concerned is filled with liquid cargo of specific gravity ρ up to the top of tank.

(c) The section modulus of deck transverses in centre tanks are to be multiplied by ρ.

(d) The values of ρ are to be selected for respective cases except those contained in **Table 7.1.1.**

Table 7.1.1 Value of ρ

Cargo	ρ
Molasses	1.4
Asphalt	1.1
Concentrated sulphuric acid	1.85

(2) For tankers carrying dangerous chemicals in bulk, the requirements in **Ships Carrying Dangerous Chemicals in Bulk** of the Rules are also to be applied.

4. For dedicated asphalt carriers of which all cargo tanks are independent type, visual inspection should be possible of at least one side of the inner hull structure without the removal of any fixed structure or fitting. For the purpose of **4.**, the following shall apply:

(1) where it is required to pass between the surface to be inspected, flat or curved, and structures such as deck beams, stiffeners, frames, girders, etc., the distance between that surface and the free edge of the structural elements shall be at least 380 mm. The distance between the surface to be inspected and the surface to which the above structural elements are fitted, e.g. deck, bulkhead or shell, shall be at least 450 mm for a curved tank surface (e.g. for a type C tank), or 600 mm for a flat tank surface (e.g. for a type A tank) (see **Fig 7.1.2**);

(2) where it is not required to pass between the surface to be inspected and any part of the structure, for visibility reasons the distance between the free edge of that structural element and the surface to be inspected shall be at least 50 mm or half the breadth of the structure's face plate, whichever is the larger (see **Fig 7.1.3**);

(3) if for inspection of a curved surface where it is required to pass between that surface and another surface, flat or curved, to which no structural elements are fitted, the distance between both surfaces shall be at least 380 mm (see **Fig 7.1.4**). Where it is not required to pass between that curved surface and another surface, a smaller distance than 380 mm may be accepted taking into account the shape of the curved surface;

(4) if for inspection of an approximately flat surface where it is required to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces shall be at least 600 mm. Where fixed access ladders are fitted, a clearance of at least 450 mm shall be provided for access (see **Fig 7.1.5**);

(5) the minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well shall not be less than those shown in **Fig 7.1.6** (**Fig 7.1.6** shows that the distance between the plane surfaces of the sump and the well is a minimum of 150 mm and that the clearance between the edge between the inner bottom plate, and the vertical side of the well and the knuckle point between the spherical or circular surface and sump of the tank is at least 380 mm). If there is no suction well, the distance between the cargo tank sump and the inner bottom shall not be less than 50 mm;

(6) The distance between a cargo tank dome and deck structures shall not be less than 150 mm (see **Fig 7.1.7**);

(7) fixed or portable staging shall be installed as necessary for inspection of cargo tanks, cargo tank supports and restraints (e.g. anti-pitching, anti-rolling and anti-flotation chocks), cargo tank insulation etc. This staging shall not impair the clearances specified in (1) to (4).

(8) if fixed or portable ventilation ducting shall be fitted in, such ducting shall not impair the distances required under (1) to (4).

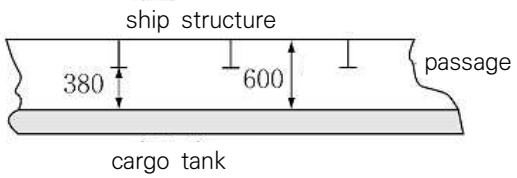


Fig 7.1.2

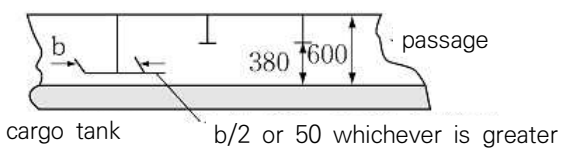


Fig 7.1.3

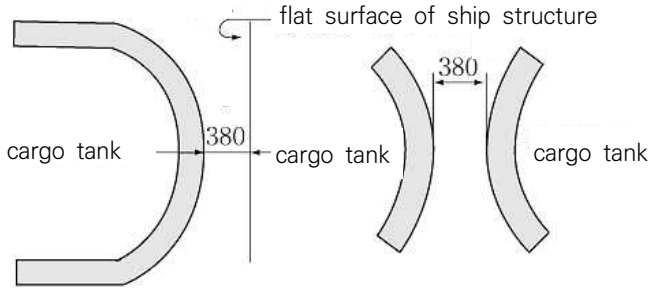


Fig 7.1.4

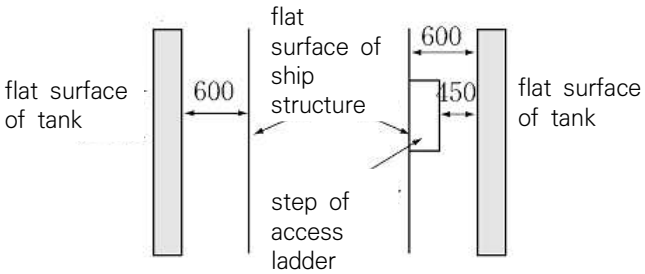


Fig 7.1.5

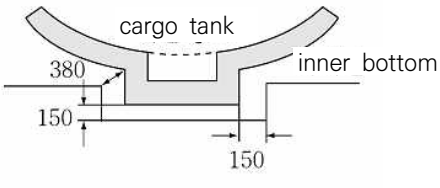


Fig 7.1.6

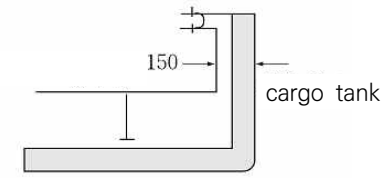


Fig 7.1.7

102. Arrangement of bulkheads in cargo tanks 【See Rule】

1. The length of tanks in cargo oil spaces is less than the greater 10 m or the following value.

(1) Where the longitudinal bulkhead is not installed ---------- $0.1L_f$

(2) Where the longitudinal bulkhead is only installed at centreline ---------- $0.15L_f$

(3) Where two or more longitudinal bulkheads are installed

(A) Wing tank ---------- $0.2L_f$

(B) Centre tank

(a) for $\frac{b_i}{B_f} \geq \frac{1}{5}$ ---------- $0.2L_f$

(b) for $\frac{b_i}{B_f} < \frac{1}{5}$

(i) Where the longitudinal bulkhead, which is not on the centreline : $\left(0.5\frac{b_i}{B_f}+0.1\right)L_f$

(ii) Where the longitudinal bulkhead, which is on the centreline : $\left(0.25\frac{b_i}{B_f}+0.15\right)L_f$

b_i = the minimum breadth at location on the load line of the wing tank.(m)

2. In the centre tanks and inner tanks, transverse swash bulkheads are to be provided at an interval not exceeding 15 m or $0.1L$, whichever is greater.

3. In wing tanks, rings and/or girders are to be so constructed as to avoid discontinuity of strength at

the positions of longitudinal bulkheads in the centre tanks and inner tanks.

103. Cofferdams 【See Rule】

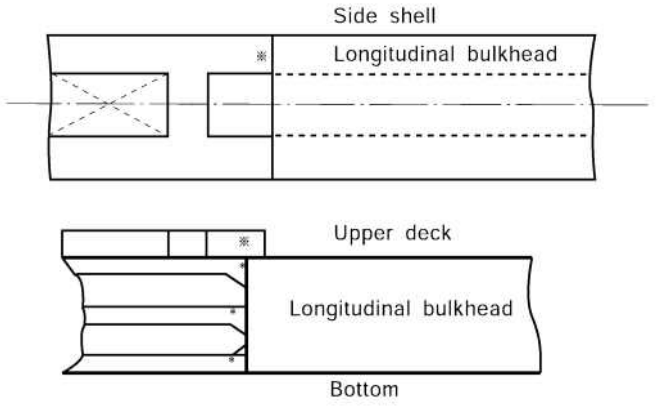
1. Cofferdams and bulkheads bounding cargo oil tanks

(1) Compartment destined to carriage of fuel oil or water ballast may be utilized as cofferdams needed for isolation from cargo tanks, if such compartments are of all welded construction except deck stringer angles. (See **1003. 2** and **3** of the Rules)
It is recommended that tanks containing such liquid cargoes as will be heavily damaged by contamination of fuel oil-gasoline, molasses, etc. be isolated by cofferdams from fuel oil tanks.
(2) If the fore peak compartment (or tank) is continuous to cargo tanks, the collision bulkhead is not to have any opening except special cases. (See **1003. 2** and **3** of the Rules)
(3) Divisions between compartments defined as cofferdams and other compartments (except cargo oil tanks and fuel oil tanks) are not to have any openings with the exception of bolted watertight manholes provided in chain locker bulkheads, etc. (no watertight door is permitted).

2. Superstructures and deckhouses

The deckhouse protecting the entrance to pump rooms is to be as follows:
(1) The strength of front wall is to be equivalent to that of wall of the bridge.
(2) The strength of side and after walls are to be equivalent to that of front wall of the poop.
(3) The height of doorway coaming is not to be less than 600 mm above the freeboard deck.

3. At the after end of cargo tank region, attention is to be given to keep continuity between the ends of longitudinal bulkheads and the longitudinal members of poop deck, etc. (See **Fig 7.1.8**)



※ : The wall of deckhouse is to be of steel, and be provided on the longitudinal bulkhead.
* : The brackets are to be of big size.

Fig 7.1.8 Continuity of after end of longitudinal bulkhead

4. Tankers having double bottoms under cargo tanks

Access to the double bottoms is not to be provided in cargo tanks. It is to be made from cofferdams at the forward and after ends or through oiltight trunks led from the exposed main deck to the double bottom.

104. Airtight bulkheads 【See Rule】

1. Cofferdams which are not utilized as main or auxiliary pump rooms and compartments utilized as cofferdams under the freeboard deck are to meet the requirements for the strength of deep tanks. The bulkhead between the main pump room and engine room is to have structural scantlings of watertight bulkheads in ships of not less than 100 m in length and of airtight bulkheads in ships of less than 100 m in length.

2. The scantlings of airtight bulkheads for which no hydrostatic tests are required are to comply with

the following standards. Airtightness tests may be replaced by hose tests.

(1) Thickness : It is not to be less than 6 mm, which may, however, be reduced to 4.5 mm in ships of less than 100 m in length.
(2) Section modulus of stiffeners and girders : It is to be 50 % of the rule requirements for watertight bulkheads. Where connected to shell and decks, however, these stiffening members are to be of such an effectiveness as is equivalent to frames and beams.

109. Direct strength calculation 【See Rule】

When determining the scantlings of structural members of cargo hold for a tanker by direct strength calculations, the procedure is to comply with the **Pt 3, Annex 3-2** Guidance **for the Direct Strength Assessment** of the Guidance.

110. Stability Instrument 【See Rule】

1. In applying the requirements in **110.** of the Rules, the performance standards recommended by the Organization refer to following:

- part B, chapter 4, of the International Code on Intact Stability, 2008 (2008 IS Code)
- the Guidelines for the Approval of Stability Instruments (MSC. 1/Circ.1229), annex, section 4;
- the technical standards defined in part 1 of the Guidelines for verification of damage stability requirements for tankers (MSC.1/Circ.1461)

2. In applying the requirements in **110. 1** (3) of the Rules, "where deemed appropriate by the Society" means that the following ships provided the procedures employed for intact and damage stability verification maintain the same degree of safety, as being loaded in accordance with the approved conditions.

(1) ships which are on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved in the stability information provided to the master;
(2) ships where stability verification is made remotely by a means approved by the Society;
(3) ships which are loaded within an approved range of loading conditions; or
(4) ships constructed before 1 January 2016 provided with approved limiting KG/GM curves covering all applicable intact and damage stability requirements.

3. In applying the requirements in **2.**, “the approved conditions” refer to following:

- operational guidance provided in part 2 of the Guidelines for verification of damage stability requirements for tankers (MSC.1/Circ.1461).

Section 2 Hatchways, Gangways and Freeing Arrangement

201. Ships having unusually large freeboard 【See Rule】

In application to **201.** of the Rules, the term "considered" means **203. 2** (2) (E) of the Guidance.

202. Hatchways to cargo oil tanks *(2018)* 【See Rule】

1. In case where hatchway covers of glass-fibre reinforced plastics are provided for cargo oil tanks, they are to comply with the following requirements:

(1) The basic materials is to be of fire-resistant nature.
(2) Model tests are to be carried out according to the standard fire test method specified in SOLAS 1974 (including amendments 1981/ 1983) through exposing the inside face to fire. This standard fire test is to be carried out for a time duration of not less than 20 minutes at a highest temperature of 790℃ to confirm that there is no passage of flame until the end of the first 20 minutes of the test.
(3) Steaming tests are to be carried out to confirm that no deformations causing leakage occur.
(4) Each model of different dimensions is to be subject to hydraulic test with a pressure not less than 0.028 MPa to confirm its strength.
(5) The cover is to be designed to be set either at full-open position or full-close position only. A

notice indicating this manner of handling is to be fitted to the upper surface of cover.

2. Materials of tank cleaning hatch covers are to comply with the following requirement.

(1) Covers may be of brass, bronze or steel, but are not to be of aluminium.

(2) Synthetic materials such as glass-fibre reinforced plastics materials may be used only when all the requirements under **Par 1** above can be met.

3. The tightening devices of covers of tank-cleaning hatches are to be capable of keeping an ample tightness under pressure corresponding to water head of 2.45 m above the tank top. If the devices are constructed in any of the types mentioned below or in their equivalent type, the height of hatch coamings may be reduced in accordance with the provisions of **Pt 4, Ch 2, 103. 1** of the Rules.

(1) In such a type of construction that a liner is placed on the tank top and the cover is tightened by means of bolts, the pitch between these bolts is not to exceed 150 mm, and the number of bolts is not to be less than 10. Any constructions using butterfly-nuts, etc., which can be opened by simple manipulations, is not permitted. The liners are to be of a same material as the upper deck.

(2) The hatch of a type having hinged cover with arm is to have a coaming. The construction is to be such that the hatch cannot be opened simply by hand. (See Fig **7.1.9**)

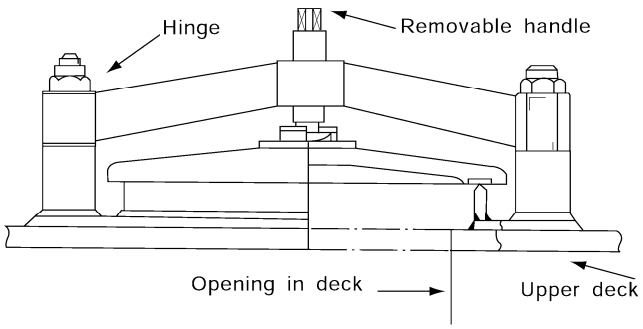


Fig 7.1.9 Cover of tank cleaning hatch

204. Permanent gangway and passage 【See Rule】

In application to **204. 1** of the Rules, the term "the satisfaction of the Society" means **Pt 4, Ch 4, 501** of the Guidance.

205. Freeing arrangement 【See Rule】

In application to **205. 1** of the Rules, Open guardrails for a length not less than half of the length of the exposed parts of the freeboard deck may be replaced by freeing ports, in the lower parts of bulwark, of a total area not less than 33 % of the total area of bulwarks.

Section 3 Longitudinal Frames and Beams in Cargo Oil Spaces

302. Scantlings 【See Rule】

1. Slenderness ratio

In 0.4 L amidships, the slenderness ratios of longitudinal beams and longitudinal frames attached to sheer strakes are not to exceed 60 for the large ships and 80 for the small ships. In the calculation of slenderness of ratio, the dimensions of attached plate to be included into calculation are to be (actual spacing of beams or frames) × (actual plate thickness).

2. Side longitudinal

In calculating the side longitudinals as bulkhead stiffeners of deep tanks, h in the formula in the Rules is to be that in **510.** of the Rules, if the length or breadth of side tanks exceeds 10 m.

303. Attachment 【See Rule】

1. At the intersection of transverse bulkheads, longitudinal frames and beams marked with ○ in **Table 7.1.2** are to be connected by means of through-brackets or they are to penetrate.

Table 7.1.2 Where through-brackets are needed

L (m)	$90 \le L \le 120$	$120 \le L$
Longitudinal beams and side longitudinals attached to sheer strakes	○	○
Side longitudinals and longitudinals on longitudinal bulkhead (except those specified above)	—	○1)
Bottom longitudinals and longitudinals on bilge strake	○	○
Note: (1) The manner of penetration of longitudinals may be as shown in **Fig 7.1.10**, except side longitudinals within 0.2D from top and bottom and longitudinals on longitudinal bulkhead within 0.1D from top and bottom		

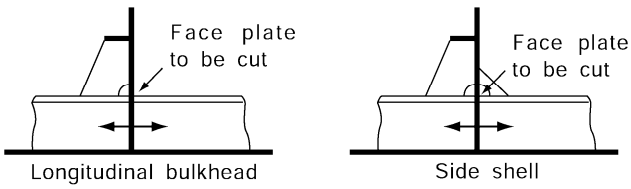


Fig 7.1.10

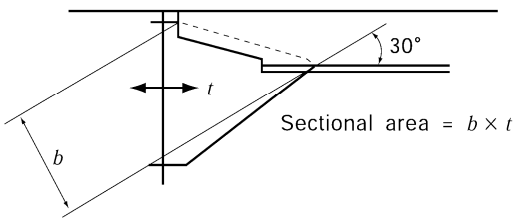


Fig 7.1.11

2. The calculation of sectional area of end bracket is to be as shown in **Fig 7.1.11** so that the area may not be less than the sectional area of the longitudinal beam, frame or stiffener concerned.

3. The connection of end brackets and longitudinal frames or beams is to be as follows.

(1) In ships of 120 m and above in length, the end brackets and longitudinal beams or frames are to overlap each other for an ample length as shown in **Fig 7.1.12.**

(2) In cases other than those under (1) above, the arrangements may be as shown in **Fig 7.1.13.** The bracket is to be brought as close to the plane of web of longitudinal as possible. Where the

longitudinals are of flanged plate, the bracket is to be placed on the line of end of curvature and, further, ribs are to be fitted at a point about 10 mm inward of the toe of bracket.

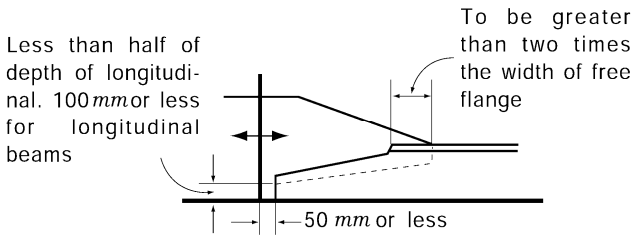


Fig 7.1.12

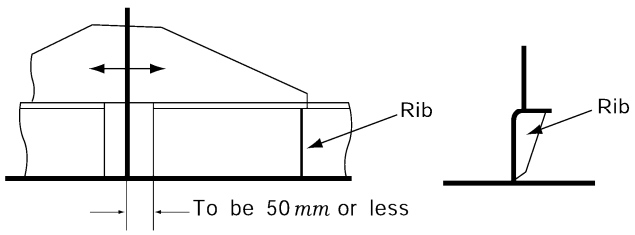


Fig 7.1.13

4. The connection of transverse bulkheads and brackets are to be rounded or levelled, as shown in **Fig 7.1.14.**

(1) The penetrating parts of end brackets are to be rounded or bevelled, as shown in **Fig 7.1.14.**

(2) The connection of end brackets and bulkhead plating is to be reinforced to avoid hot spots, as shown in **Fig 7.1.15.**

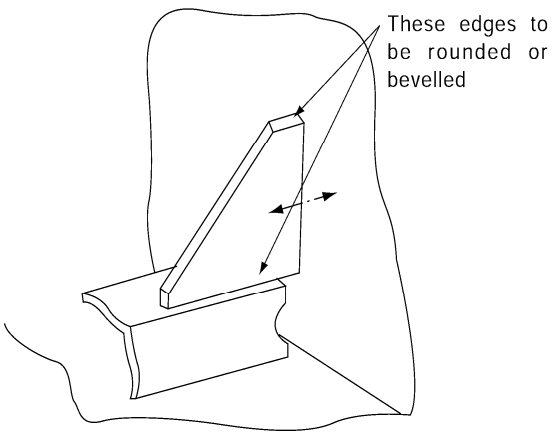


Fig 7.1.14

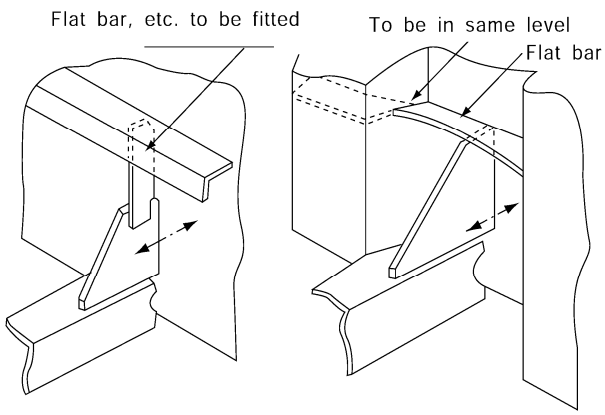


Fig 7.1.15

Section 4 Girders, Transverses and Cross Ties in Cargo Oil Spaces

401. General 【See Rule】

1. The dimension and locations of lightening holes, if any, are to be as shown in **Fig 7.1.16.**
2. Slots are to be reinforced with collars where flanges of longitudinals are facing each other or where slots are provided at small intervals as is often the case with bilge part.
3. Where the depth of a girder is smaller than the required depth, its section modulus is to be obtained through multiplying the required section modulus by the ratio of required depth to the actual depth.
4. In pump rooms or void spaces, the web thickness may be 1 mm smaller than the required thickness for webs in cargo oil tanks.
5. The scantlings of members in segregated ballast tanks in the midship part are to be same as those of members in cargo oil tanks (**401. 5** of the Rules)
6. Connection of web plates is to be of butt-welding. If lap-welding is adopted, stiffeners are to be provided across the connection lines.

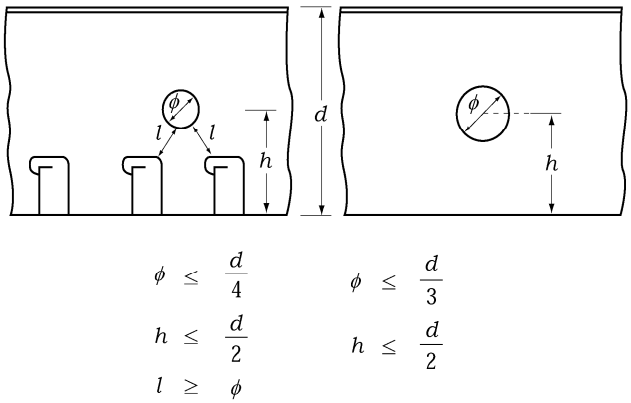


Fig 7.1.16 Locations and dimensions of lightening holes

7. In end bracket parts, at connections with cross ties, etc. of transverses where sharing stress and/or compressive stress are expected to be high, additional stiffeners are to be fitted. These parts are not to have lightening holes. If considered necessary, slots for penetration of longitudinals in these parts are to be reinforced with collars.
8. No scallop is to be permitted in the web plate at the connections of face plates or webs. Inevitable scallops for work are to be filled up by welding. For face plates adjacent to the scallop, abrupt change of dimensions is to be avoided carefully. (See **Fig 7.1.17**)

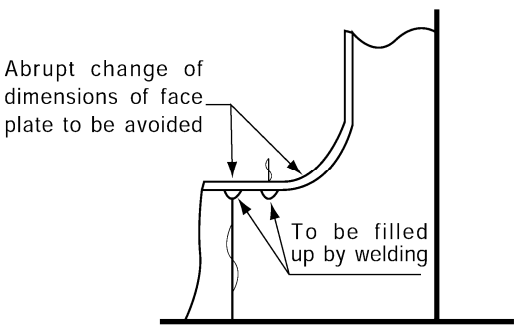


Fig 7.1.17

9. Where angle bars are used instead of flat bars as stiffeners of transverses, etc., their section modulus with effective plates is to be approximately equivalent to the required ones.

10. Where longitudinal frames or stiffeners penetrate bottom transverses, side transverses and vertical webs on longitudinal bulkhead, proper reinforcement is to be made in the extents stipulated in **Table 7.1.3** by fitting brackets on the opposite side of stiffeners on webs of transverse, for connecting longitudinals to transverse, by fitting collars at slots, or by other suitable means. In ships not exceeding 230 m in length, however, the extent of application of such reinforcement may be properly reduced. This reinforcement is to apply to the slots under conditions similar to those in the above-mentioned girders or transverses(for example, slots in transverse swash bulkheads, etc.)

Table 7.1.3 Extents of reinforcement

Member	Extent of reinforcement
Bottom transverse	All connections
Side transverse	All connections below the upper end of curvature of upper cross tie, or the load waterline, whichever is the higher. In ships of 300 m and above in length, it is recommended that similar reinforcement be applied in wider extent upward beyond the limit stipulated above.
Vertical webs on longitudinal bulkhead	All connections below the upper end of curvature of upper cross tie.

402. Transverses and girders provided in centre or inner tanks in ships having two or more rows longitudinal bulkheads 【See Rule】

1. Where transverse swash bulkheads complying with rule requirements are provided in tanks, L_0 may be the distance between the transverse bulkhead and the swash bulkhead.

2. As for the treatment of Note 1 to **Table 7.1.3** of the Rules, the value of C_4 is to be equal to 1.2 times the value of C_4 in **Table 7.1.3** of the Rules.

3. As for the treatment of Note 2 to **Table 7.1.3** of the Rules, the value of C_4 in **Table 7.1.3** of the Rules, may be multiplied by $0.25D/d_1$, if the depth of the centreline bottom longitudinal girder d_1 exceeds 25 % of the ship's depth D.

4. The centreline bottom longitudinal girder is to have docking brackets at the middle of span between bottom transverses and between the bottom transverse and transverse bulkhead. If these brackets are of large dimensions, their free edges are to be reinforced against buckling.

5. Where the depth d_2 of centreline vertical web on transverse bulkhead is greater than the spacing S of transverses, the web thickness of bottom girders is to be obtained form the formula in Rules, where d_1 is to be used in place of d_1' and the coefficient η is to be derived form **Table 7.1.4.** (See **Fig 7.1.18**)

Table 7.1.4 Coefficient η

Number of transverse	η
2	0.55
3	0.67
4	0.75
5	0.80

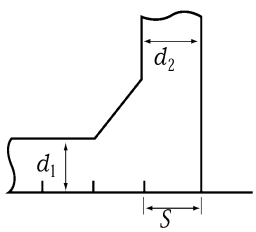


Fig 7.1.18

403. Transverses and girders in wing tanks in ships having two or more rows of longitudinal bulkheads 【See Rule】

1. Side transverse

The span l_0 of side transverses is to be measured as shown in **Fig 7.1.19.** The lower end is to be determined in a similar manner.

2. Vertical webs on longitudinal bulkheads

(1) Even when large brackets are provided on the opposite side of longitudinal bulkhead, the span l_0 and radius of transverses are to be measured on the wing tank side in a same manner as (1) above. The size of bracket b may be $(b'+b'')/2$, except when b is to be taken as equal to b' if b'' is smaller than b'.(See **Fig 7.1.20**)

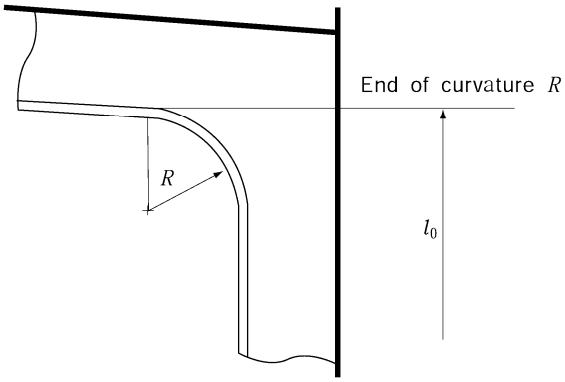


Fig 7.1.19 Measurement of l_0

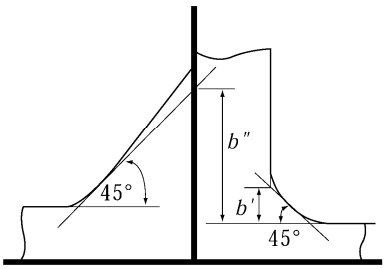


Fig 7.1.20 Measurement of b' and b''

(2) In calculating the web thickness in regard to the shearing force, the brackets on the opposite side of longitudinal bulkhead may be taken into account.
(3) Collars are to be fitted to close slots in the vicinity of the toe of bracket of bottom transverse, which is connected to longitudinal bulkhead, in the centre tank or inner tank.
(4) Girders on corrugated bulkheads are to be balanced girders. Where balanced girders are not adoptable, the neutral axis is to be brought as close to bulkhead plating as possible.

3. Moment of inertia of bottom and deck transverses

The standard values of moment of inertia of bottom and deck transverses are to be obtained from the following formulae :

Bottom transverses : $I = 160 C_0 C_2 Q l_0^2 \frac{B_S}{D} \quad (\mathrm{cm}^4)$

Deck transverses : $I = 58 C_0 C_2 Q l_0^2 \frac{B_S}{D} \quad (\mathrm{cm}^4)$

where:
C_0 and C_2 = as specified in **Table 7.1.3** of the Rules
Q and l_0 = as specified in **403. 1** of the Rules
B_S = breadth of wing tank

4. Transverses at bilge part and lower end of longitudinal bulkhead

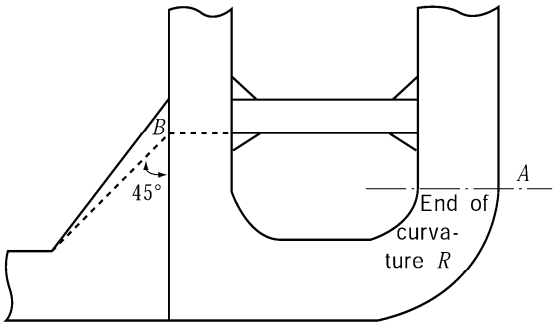
If the lowest cross tie is located as shown in **Fig 7.1.21** the section modulus of transverse at the bilge part and the lower end of longitudinal bulkhead may be reduced to 90 % of the values obtained from the formula. Further, the web thickness of side transverse at "A" may be 0.5 mm thinner than that obtained from the formula, but is not to be less than the thickness according to **405.** of the Rules.

5. Where side stringers are provided

(1) If a swash bulkhead is provided in the centre tank, l_1 is to be measured as shown in **Fig 7.1.22.**

(2) In addition to the prescriptions in **403. 5** (1) of the Rules, the side stringers and cross ties are to meet the following condition.

$l_1 > l_2 > l_3$ ---------- (See **Fig 7.1.23**)



The lower face of cross tie should be located at least lower than the point "B"

Fig 7.1.21

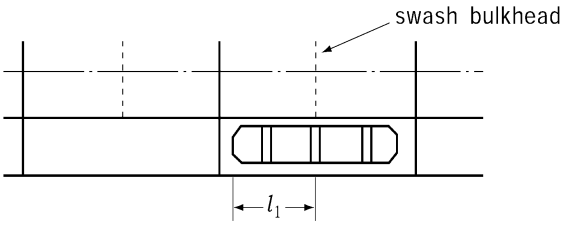


Fig 7.1.22 Measurement of l_1

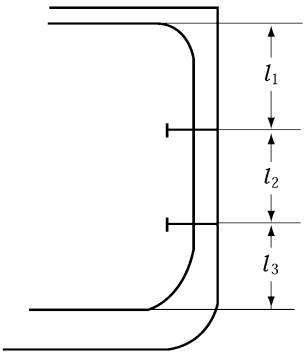


Fig 7.1.23

(3) Where four transverse rings and one horizontal ring are connected by one cross tie, the co-efficients C_3 and C_4 for calculation of the scantlings of horizontal ring are to be obtained from **Table 7.1.5. 404. 2** is to apply to the cross tie.

(4) If stringers are arranged asymmetrically or two cross ties are provided, the scantlings of these members are to be decided on the basis of equivalent effectiveness.

Table 7.1.5. C_3 **and** C_4 **of coefficient**

Coefficient		C_3	C_4
$K=\frac{d_0}{d_1}\left(\frac{l_1}{l_0}\right)^2$	$K \leq 0.2$	62	5.32
	$0.2 < K \leq 0.3$	54	4.51
	$0.3 < K \leq 0.4$	50	4.22
	$0.4 < K \leq 0.5$	48	3.92
	$0.5 < K \leq 0.6$	45	3.62
	$0.6 < K \leq 0.7$	43	3.40
	$0.7 < K \leq 0.8$	41	3.18
	$0.8 < K \leq 0.9$	40	3.03
	$0.9 < K \leq 1.0$	38	2.88
	$1.0 < K \leq 1.2$	36	2.66
	$1.2 < K \leq 1.4$	33	2.44
	$1.4 < K \leq 1.6$	32	2.30

6. Side stringers in bow part(longitudinal bulkhead in centreline only)

(1) Where strong stringers support transverse rings(without cross tie) (See **Fig 7.1.24**)

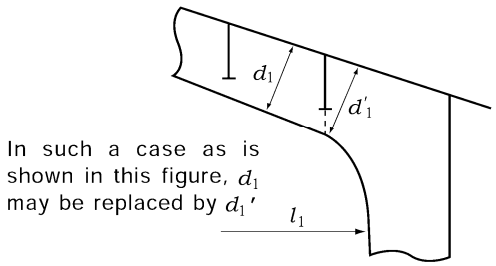


Fig 7.1.24

Transverse ring:

Average depth of girder : $d = C_0\, l_0 \quad (\mathrm{m})$

Section modulus of girder :

average over span : $Z = C_2 K^2 Q\, l_0 \quad (\mathrm{cm}^3)$

bilge part : $Z = C_2' Q\, l_0 \quad (\mathrm{cm}^3)$

Longitudinal girder :

Web thickness : $t = C_3 \frac{Q}{d_1} + 2.5 \quad (\mathrm{mm})$

Section modulus of girder : $Z = C_4 K Q\, l_1 \quad (\mathrm{cm}^3)$

C_0, C_2, C_2', C_3 and C_4 are to be obtained from **Table 7.1.6.** These formulae apply to the type of construction comprising three or four transverse rings supported by one or two strong stringers, where K does not exceed 0.5. Symbols are to be as per **403.** of the Rules.

(2) Where the side transverse is connected by cross ties to the vertical webs on the centreline bulkhead (without longitudinal girders), the principal scantlings are to be determined according to **403. 1** (1) to (4), **2** (1) and **3** (3) of the Rules, in which the coefficient in formulae may be those in **Table 7.1.7.** The prescriptions in **404.** of the Rule are to apply to cross ties.

404. Cross ties 【See Rule】

1. In the construction of 4 transverses ring/1 cross ties or 4 transverses ring/ 2 cross ties type as per **403. 5** (3), the value of S in the formula is to be obtained from the following formulae.(See **Fig 7.1.25**)
2. In such a construction as shown in **Fig 7.1.26,** brackets asterisked are to be fitted.

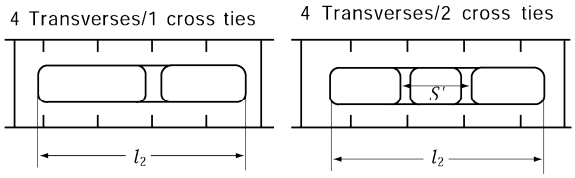
Table 7.1.6 Coefficient C_0, C_2, C_2', C_3 and C_4

No. of longitudinal girders	No. of transverses	Coefficient	$K=\frac{d_0}{d_1}\times\left(\frac{l_1}{l_0}\right)^2$	
			0	0.5
1	3 or 4	C_0 C_2 C_2'	0.080 1.46 2.89	0.125 3.88 5.10
	3	C_3 C_4	54 10.20	36 5.60
	4	C_3 C_4	72 10.60	45 6.40
2	3 or 4	C_0 C_2 C_2'	0.065 0.68 1.36	0.115 3.40 4.76
	3	C_3 C_4	41 7.20	23 3.80
	4	C_3 C_4	50 7.7	32 4.3

Note:
Where only two transverse rings are provided, C_3 and C_4 are to be replaced by $1.2C_3$ and $1.2C_4$, respectively, for the lower longitudinal girder and $0.8C_4$, respectively, for the upper longitudinal girder.

Table 7.1.7 Coefficient C_0, C_2 and C_2'

Coefficient \ No. of cross tie	1	2
C_0	0.10	0.09
C_2	2.52	1.94
C_2'	3.83	2.89



$$S = \frac{l_2}{2} \quad (m) \qquad S = \frac{l_2 + S'}{4} \quad (m)$$

l_2 = span of longitudinal girder/stringer (m).
S' = spacing of cross ties (m).

Fig 7.1.25 Value of S

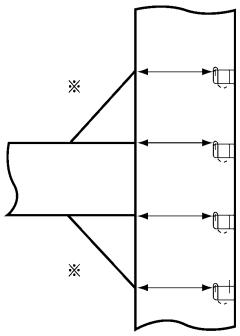
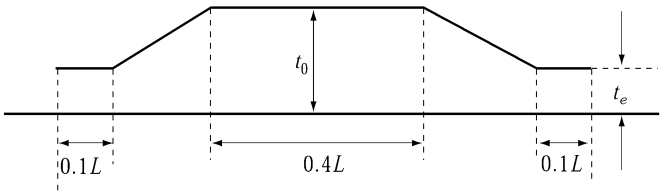


Fig 7.1.26

Section 5 Bulkheads in Cargo Oil Spaces

502. Thickness of bulkhead plating

The thickness of the uppermost and the lowest strake of longitudinal bulkheads stipulated in **502. 2** may be tapered down as shown in **Fig 7.1.27,** provided that their thickness is not less than obtained according to **502. 1** and **3** of the Rules. **【See Rule】**



t_0 = actual thickness in midship part ⓧ
t_e = thickness as per Rules, **Table 7.1.1**

Fig 7.1.27 Tapering of thickness of uppermost and lowest strakes of longitudinal bulkhead

504. Strong vertical webs 【See Rule】

1. Centreline vertical webs on transverse bulkhead

d_l and d_u in the prescriptions in **504.** of the Rules are to include the depth of brackets, if there are brackets on the opposite side of the bulkhead.

2. End connection of webs attached to bulkheads

The connection of a member having a large moment of inertia, such as longitudinal girder on bulkhead, and a member having a small moment of inertia, such as longitudinal frames, is to be arranged as shown in **Fig 7.1.28.**

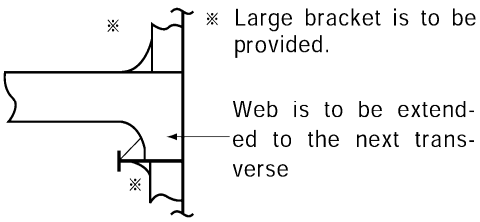


Fig 7.1.28

506. Horizontal girders supporting vertical webs 【See Rule】

Connection of webs and longitudinal frames, etc. is to be as specified in **504. 2.**

511. Swash bulkheads 【See Rule】

1. The breadth and thickness of the uppermost and lowest strakes of the centreline swash bulkhead may be 90 % of those required by the Rules for the uppermost and lowest strakes, respectively, of the longitudinal oiltight bulkhead.

2. The "opening ratio" means the ratio of the sum of areas of openings, except slots and scallops, to the area of the bulkhead.

3. The section modulus of stiffeners is to be obtained from the following formula;

$$Z = C\,S\,h_s\,l^2 \quad (\mathrm{cm}^3)$$

where:

S = spacing of stiffeners (m)

l = span of stiffener between supports (m)

C = coefficients stipulated below

both ends effectively bracketed ----------7.1

one end effectively bracketed and the other end supported by girder ---- 8.4

both ends effectively bracketed ----------10.0

h_s = value obtained from the following formula. In no case is it to be less than 2.0

$$h_s = \left(0.176 - \frac{0.025}{100}L\right)(1-a)l_t$$

where :

L = length of ship (m)

a = opening ratio of bulkhead plating

l_t = length of tank (m)

4. Where a vertical web at the middle of two longitudinal bulkheads serves as a strong web supporting horizontal girders, the scantlings of the vertical web are to be obtained from the following formulae:

(1) Depth of web

$$d = 3\left(\frac{l_1}{B_0}\right)^2 d_0 \quad (\mathrm{m})$$

where:

l_1, B_0 and d_0 = as specified in **504.** of the Rules

(2) Sectional area of web at the upper end of lower bracket

$$A = 1.74\frac{(D-h_1)}{D}S(h-0.32d)(l-S)C \quad (\mathrm{cm}^2)$$

where:

S, h, l and C = as specified in **501.** of the Rules.

h_1 = vertical distance from the top of keel to the inner toe of lower bracket of the web (m)
But, the sectional area of web is to include the bulkhead plating of the part within the distance form the web to the nearest opening or the distance equal twice the deck

longitudinal spaces on each side of the web, whichever is the smaller.

(3) Thickness of web at the upper end of lower bracket

$$t = 12\ K\ b + 2.5 \quad (\mathrm{mm})$$

where:

b = spacing of vertical stiffeners fitted to web (mm)

K = as specified in following formula

$$K = \sqrt{\frac{A}{A_0}}$$

A = sectional area as specified in (2) (cm^2)

A_0 = sectional area of the vertical web (cm^2)

(4) Section modulus of vertical web

$$Z = 4\ k^2\ B_0\ h_s\ l_1^2 \quad (\mathrm{cm}^3)$$

where:

k, B_0 and l_1 = as specified in **504.** (1) of the Rules.

h_s = as specified in **Par 3.** above.

5. The scantlings of waves supporting vertical webs or horizontal girders are not to be less than obtained from the formula in **506.** of the Rules. In applying the formula for W_i, h is to be replaced by h_s prescribed in **Par 3.**

6. The scantlings of webs supporting stiffeners are to be obtained according to **507.** of the Rules in which h is to be replaced by h_s prescribed in **Par 3** and X is to be taken as zero.

7. Where a swash bulkhead consists of bottom transverses, deck transverses, side transverse, vertical webs on longitudinal bulkhead and struts, the scantlings of these webs and struts are to be obtained by applying **402., 403.** and **405.** of the Rules correspondingly. In this case, the section modulus of strut about vertical axis is not to be less than obtained from the following formula.

$$Z = 7.13\ d_0\ h_s\ l^2 \quad (\mathrm{cm}^3)$$

where:

d_0 = depth of strut (m)

l = span (m) between supports, to be equal to the breadth of side tank in case of side tanks, or to the distance between longitudinal bulkheads or between centreline vertical web and longitudinal bulkhead. If tripping brackets for the webs and transverses are provided at the ends of the face plates, l may be the distance between the face plates of transverse.

h_s = as specified in **Par 3** above.

Section 6 Relative Deformation of Wing Tanks

601. Relative deformation of wing tanks 【See Rule】

1. Special considerations for the case of exceeding limit values

It is required to submit data enough to prove that the proposed construction has an equivalent effectiveness.

2. Mean thickness in formulae

The mean thickness of plating in the formulae in **601.** of the Rules is to be obtained from the following formula.

$$t = \frac{\Sigma l_i t_i}{\Sigma l_i}$$

where :

l_i and t_i are to be taken as follows;

(1) Transverse bulkheads and perforated swash bulkheads : The thickness and breadth of each strake of the bulkhead are to be taken at the middle of the breadth of the tank as shown in **Fig 7.1.29.**

(2) Transverse rings and swash bulkheads of transverse ring type: The thickness and vertical extent of the deck transverse, transverse on longitudinal bulkhead between face bar of deck transverse and upper face bar of the uppermost strut and so on, and parts from the uppermost strut to the bottom transverse are to be taken at the middle of the breadth of the tank (at the bulkhead side if no plating is present at the middle of the breadth of the tank) as shown in **Fig 7.1.30.**

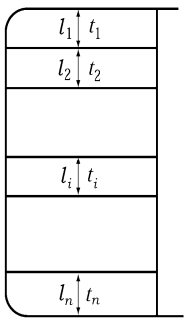


Fig 7.1.29

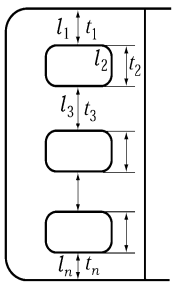


Fig 7.1.30

Section 10 Piping Systems and Venting Systems for Oil Tankers

1001. General 【See Rule】

1. In case where double bottom used as other than cargo oil tank is provided below cargo oil tank, the requirements specified in **Sec 10** of the Rules and additionally the requirements specified in the following are to be complied with ;

(1) The air pipes and sounding pipes provided in double bottom may pass through cargo oil tanks. In this case, all pipe joints in the cargo oil tanks are to be of welded joints with a sufficient thickness according to the requirements of **Table 7.1.8.** Further, consideration is to be given to the piping arrangement for expansion and contraction of the pipes.

(2) Valve operating rods are not to pass through any part subjected to liquid head at all time, such as the inner bottom plate of the cargo tank.

(3) Pipes conveying liquid and bilge suction pipes for tank or void space at the forward position of the ship are to comply with the following requirements:

(A) Pipes for tank or void space adjacent to the forward end of cargo oil tank may be led to the aft pump room. Fuel oil transfer pipes may be led to the pump provided in the engine room.
(B) Pipes for forepeak tank or void space not adjacent to cargo oil tank may be led to the pump provided in the engine room or the pump to provided in the aft pump room. Where this tank used ballast tank, ballast pipe may be led to the pipes for ballast tank adjacent to the cargo oil tank
(C) Where ballast pipes are arranged without passing through cargo oil tanks, piping for fore peak ballast tanks not located adjacent to cargo oil tanks may be led to the pipe lines for ballast tanks located adjacent to cargo oil.(As for bilge pipes, the requirements of **1003. 1.** (3) of the Rules are to apply) To the contrary, however, ballast pipes for ballast tanks located adjacent to cargo oil tanks are not to be led to the pumps which are installed in the engine room for the use of the ballast tanks not located adjacent to cargo oil tanks.

Table 7.1.8 The sounding pipes and air pipes passing through cargo oil tanks

Nominal diameter(mm)	Thickness of pipe	Reference(1)
$A < 100$	8.7	Sch. 160
$100 \leq A < 200$	11.1	Sch. 120
$200 \leq A < 250$	12.7	Sch. 80
$250 \leq A$	15.1	Sch. 80
Note: (1) Standard specified in *KSD* 3562 and *KSD* 3570		

1002. Cargo oil pumps and cargo oil piping systems, pipings in cargo oil tank, etc.

1. In case of maintaining the gastight using by the oil lubricated device specified in **1002. 1** (1) (b) of the Rules, apply to **Ch. 6, 303. 6. 【See Rule】**

2. In the provision **1002. 3** of the Rules, the changable device which the Society requires means the following device. **【See Rule】**

(1) Cargo oil tanks also used as ballast tanks
In case where a tank is used both as a cargo oil tank and a ballast tank alternatively, the cargo oil pipes, ballast pipes and vent pipes are to be arranged changeable so as to serve respective cases by giving reference to the example shown in **Fig 7.1.31.** Further, for other piping systems, the requirements for the piping systems in cargo oil tanks are to be complied with.

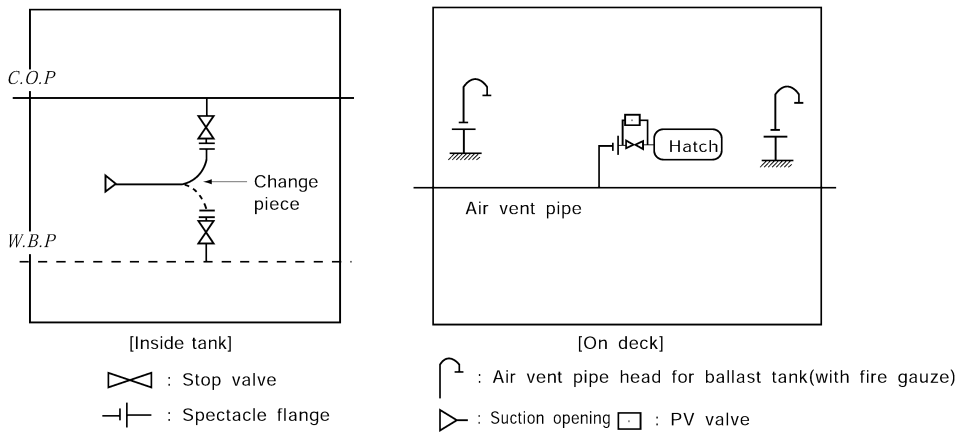


Fig 7.1.31 Example of piping arrangement for a tank used as cargo oil tank and ballast tank in alternative use

(2) Cargo oil tanks also used as fuel oil tanks
In case where a tank is used both as a cargo oil tank and a fuel oil tank alternatively the cargo oil pipes, fuel oil pipes and vent pipes are to be arranged changeable so as to serve respective cases by giving reference to the example shown in Fig **7.1.32.** Further, for other piping systems, the requirements for the piping systems in cargo oil tanks are to be complied with.

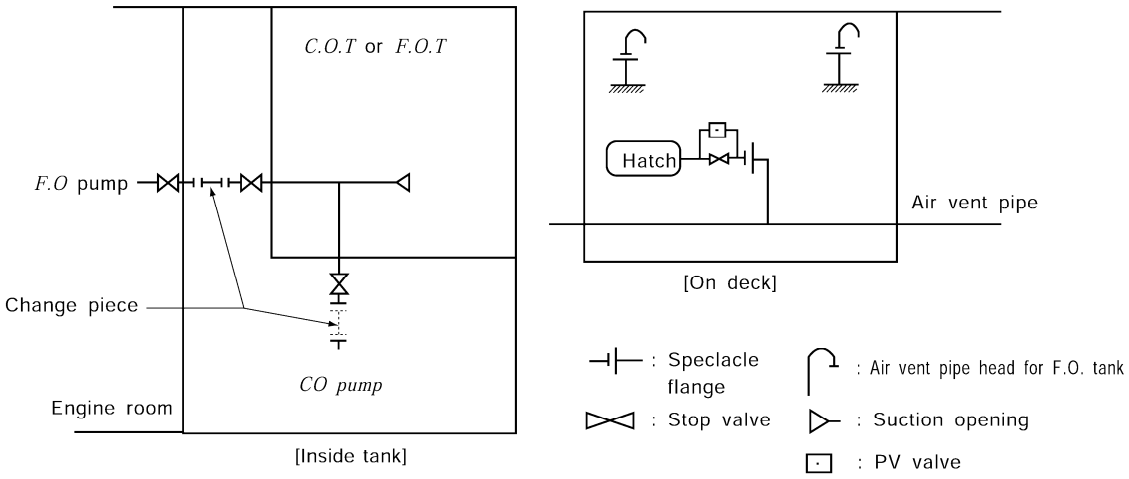


Fig 7.1.32 Example of piping arrangement for a tank used as cargo oil tank and fuel oil tank in alternative use

3. In application to **1002. 4** of the Rules, Piping systems to be connected to cargo oil piping are to be dealt with under the following requirements; **【See Rule】**

(1) Pumps and pipes in any piping system connected to cargo oil pipes are to be dealt with as those in the cargo oil piping system. However, for piping systems specified in **1002. 2** (4), **9** (6), **1003. 1** (2), **2** (2), Guidance **Pt 8. Appendix 8-5. 2 (10)(g)** and item (2) below, this requirement may be dispensed with. The piping systems connected to cargo oil piping mean those connected to cargo oil pipes having openings thereto. Hence, for example, hydraulic oil pipes for the control of cargo oil piping system are not regarded as the piping system connected to the cargo oil piping.

(2) In case where the cargo oil piping system is connected to;

(A) Tank vent pipes : The requirements in Guidance **Pt 8. Appendix 8-5 2** (10)(g) & (h) are to be complied with. Ventilating fans except inert gas blowers, are to be installed within the dangerous spaces. Where the ventilators are located in a enclosded non-hazardous area, it is to comply with the following requirements.

a) The air supply piping from the ventilator is to have automatically actuated shut-off valve and non-return valve in series.

b) The valves of a) above are to be located at the bulkhead where the air supply piping leaves the non-hazardous area, with at least the non-return valve on the outside.

c) Shut-off valve is to be opened after the ventilator has started, and automatically closed after the ventilator has stopped. Procedures for the operation of ventilators and valves are to be posted near the place of operation.

d) The intake of the ventilator is to be derived from a safe place (eg open deck) outside the ventilated space.

e) Ventilators is to be of non-sparking type.

(B) Pressure gauge pipes for cargo oil piping system (including pumps) :
The pressure gauge to which cargo oil is directly led is to be installed in the pump room or on the weather deck. However, when a stop valve is provided at the joint between the pressure gauge piping system and the cargo oil piping system, and a bulkhead valve is provided at the penetration between the engine room and the pump room, the pressure gauge may be installed in the engine room.

(C) Pipes for measuring oil content :
The sampling pipe for measuring oil content may be led to the spaces other than the dangerous spaces, when the pipe is of nominal diameter of 25 A or less, and two or more stop

valves are provided between cargo oil piping and the penetration of the casing of the non-dangerous spaces.

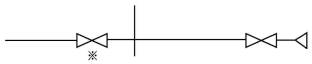
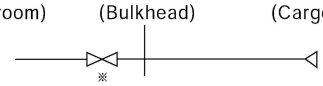
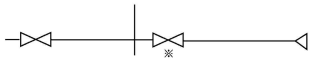
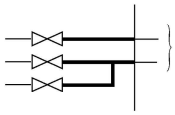
4. In application to **1002. 4.** (5) and (6) of the Rules, where at the request of the owner, cargo piping and the valve control piping are located above the double bottom, the vessel will be assigned with the notation **PCP**(Protected Cargo Piping). This applies also to cargo piping and valve control piping installed in pipe tunnel or duct keel.

5. Bulkhead valves of cargo oil piping systems

In application of **1002. 5** of the Rules, bulkhead valves in cargo oil tanks is to be comply with the following requirements. **【See Rule】**

(1) The arrangement and type of bulkhead valves are to be as given in **Table 7.1.9.**

Table 7.1.9 Arrangement and type of bulkhead valves

Arrangement A	(Pump room) (Bulkhead) (Cargo oil tank)  ※	In case where stop valve is provided at the end of opening in the cargo oil tank: No specific requirements are imposed on type and material of bulkhead valve.
Arrangement B	(Pump room) (Bulkhead) (Cargo oil tank)  ※	In case where no stop valve is provided at the end of opening in the cargo oil tank: The bulkhead valve is to be of steel castings and be operable from a control position on deck.
Arrangement C	(Pump room) (Bulkhead) (Cargo oil tank)  ※	In case where bulkhead valve is provided in the cargo oil tank: The valve on the tank side is to be operable from a control position on deck.
Arrangement D	(Pump room) (Bulkhead) (Cargo oil tank)  Piping arrangement on the cargo oil tank side is same as shown in A or B.	In cases where bulkhead valve is not provided close to the bulkhead: If those indicated with bold lines in the figure are of cast steel pipes having thickness of 13.5 mm or more or of heavy gauge steel pipes of 16 mm or more, the requirements for bulkhead valves as shown in Arrangement. A or B may be accepted.
Note: ※ This valve is to be installed as close to the bulkhead as practicable		

6. In application of **1002. 7** of the Rules, piping in cargo oil tanks is to be comply with the following requirements. **【See Rule】**

(1) Pipes for measuring instruments and remote control equipment.
Steel pipes for measuring instruments and remote control equipment provided in cargo oil tanks are to have minimum thickness of **Sch. 80.**, except when they have openings in cargo oil tanks.

(2) Scupper pipes and sanitary pipes
Scuppers draining weather decks may pass through cargo oil tanks. In this case, all of their pipe joints within cargo oil tanks are to be of welded type and wall thickness of the pipes is to be not less than 16 mm. As for the pipes of small diameter, however, consideration may be given reasonably. Scuppers or sanitary pipes from the spaces where ignition source exists such as accommodation space and others, are not to pass through cargo oil tanks. When the pipes of diameter is less than 100A, pipes of Sch. 160 specified in KSD 3570.

(3) Overboard discharge pipes (bilge or ballast pipes)
Overboard discharge pipes passing through cargo oil tanks are to be dealt with under the following requirements;

(A) Overboard discharge pipes are not to pass through the cargo oil tanks other than those having relatively small capacity (e.g., slop tanks, etc.).

(B) Such pipes thickness in cargo oil tanks are to be 16 mm and all pipe joints in cargo oil tanks are to be of welded joints. In case where cast steel pipes are used, the pipe thickness may be 15 mm or more.

(C) Bent pipes are to be provided adequately to absorb the expansion and contraction of the pipe line.

(D) Internal surface of the pipe is to be coated with paints of good corrosion resistance, except where cast steel pipes specified in (b) above or steel pipes of adequate thickness considering corrosion allowance are used.

(E) The pipes are to be supported firmly enough to withstand vibration of ship, and to be so ar-

ranged as to enable maintenance and inspection to be carried out satisfactorily after ships are in service. As to the construction and workmanships of the penetration part of shell platings and bulkheads, special care is to be given.

(F) No valves are to be provided in cargo oil tanks.

7. The sounding device of cargo oil tanks is to be of the construction capable of measuring the ullage without opening the tank hatch cover and installed separately from the opening provided in accordance with the requirements of **1002. 8** of the Rules. **【See Rule】**

(1) Means for ullage measurement of cargo oil tanks are to be such as can make the measurement without opening the tanks.

(2) When sounding pipe is provided, the open end is to be led to the weather deck and to be provided with the pipe heads having a sluice valve or cock fitted with an automatic closing device.

(3) In case where level indicating device is provided, the device is to be of the one approved in accordance with the requirements of the 「**Guidance for the Approval of Manufacturing Process and Type approval. etc**」.

(4) Level indicating device fitting to cargo oil tank of tanker, which is fitted with fixed inert gas system, are to be fixed and closed type.

1003. Piping systems for cargo oil pump rooms, cofferdams and tanks adjacent to cargo oil tanks

1. The open ends of sounding pipes specified in **1003. 1** (4) of the Rules may be provided in pump room. However, that when the open end is lower than the bulkhead deck, the requirements in **Pt 5, Ch 6, 203. 2** (2) of the Rules are to be complied with. **【See Rule】**

2. In application of the **1003. 2** (2) of the Rules, ballast piping system for ballast tanks is to be dealt with under the following requirements: **【See Rule】**

(1) Ballast tanks which are not adjacent to cargo oil tanks and defined as being safe are to be ballasted and deballasted by pumps which are located in gas safe area. However, they may be deballasted by pumps which are located in dangerous area, provided that a check valve fitted on the line for only deballast.

(2) In case where ballast tanks adjacent to cargo oil tanks are intended to be deballasted by cargo oil pumps in an emergency, a spool piece(or blank flange) and a screw-down non-return valve are to be provided on each ballast pipe at the joint with the cargo oil pipe. Further, a warning notice is to be posted stating that spool pieces are to be removed except for emergencies.

3. In the apply to the **1003. 2** (3) of the Rules, Air vent pipes of ballast tanks adjacent to cargo oil tanks is to be dealt with under the following requirements; **【See Rule】**

(1) The wording "flame screen" specified in **1003. 2** (3) of the Rules means the screen meeting the following requirements:

(A) To be made of corrosion resisting material.

(B) To comprise two fitted screens of at least 20 × 20 mesh spaced 25.4 ± 12.7 mm apart or single fitted screen of at least 30 × 30 mesh, or to have a performance equivalent thereto

(2) The total sectional area of air vent pipes in case where high level alarm or hatchway specified in **202.** of the Rules is provided in ballast tanks adjacent to cargo oil tanks may be larger than the sectional area under the requirements of **Pt 5, Ch 6, 201. 4** (1) of the Rules or 1,000 cm^2 whichever is the smaller.

4. In application of **1003. 2** (4) of the Rules, the open ends of sounding pipes for ballast tanks adjacent to cargo oil tanks is to be comply with **1003. 1. 【See Rule】**

5. In application of **1003. 4** of the Rules, the open ends of sounding pipes for fuel oil tanks adjacent to cargo oil tanks is to be comply with **1003. 1. 【See Rule】**

1005. Venting systems of cofferdams adjacent to cargo oil tanks 【See Rule】

The wording "flame screen" specified in **1005.** of the Rules means the one specified in **1003. 4** (1).

1006. Positions of openings of machinery spaces, deck house, etc. and electrical equipment, etc. 【See Rule】

Where cargo pipe is provided to stern regard as dangerous spaces within 3 m from opening.

1007. Tankers carrying only oils having flash point exceeding 60°C

Ventilation system specified in **1007. 6** of the Rules may be deduct 6 times from ventilation frequency and may not non-sparking construction. **【See Rule】**

Section 11 Electrical Equipment of Oil Tankers

1101. General 【See Rule】

1. The term "semi-enclosed spaces" specified in **1101. 2** of the Rules means the spaces separated by decks and bulkheads where the condition of ventilation is significantly different from that of exposed part of ship.

2. In the case of small ships where part of the forecastle deck corresponds to the dangerous space under the requirements of **1101. 2** (1) (B) (k) & (C) (e) of the Rules and when electrical equipment other than explosion-protected ones are installed under an inevitable reason, the following requirements are to be complied with:

(1) A steel gas barrier is to be provided on the forecastle deck.
(2) The height of the steel gas barrier is to be 2.4 m or more above the upper deck with the full width of the forecastle deck where the steel gas barrier is installed.
(3) The steel gas barrier is not to be provided with any opening.
(4) Electrical equipment is to be at least of the totally enclosed water-proof type.

3. The requirement of **Pt 1101. 3** (2) (D) apply to the following circuit.

(1) Condenser circuit for filter
(2) Earthing circuit for composing intrinsic safety circuit
(3) Neutral circuit of 3000 V and above high voltage 3 phase distribute cabling in main machinery, special safety area. etc.

4. Examples of dangerous spaces for **1101. 2** of the Rules are classified as follows.

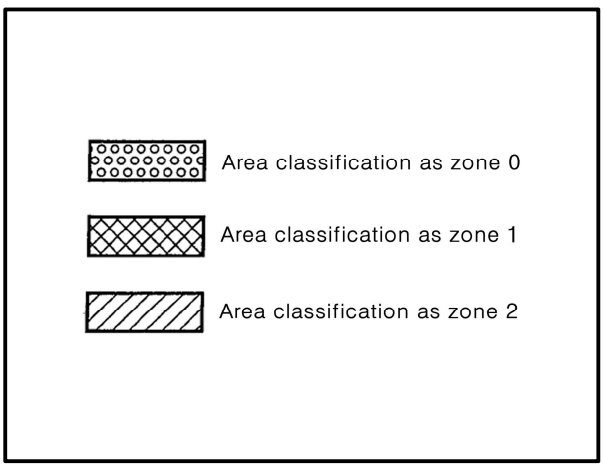


Fig 7.1.33 Classification symbols of dangerous spaces

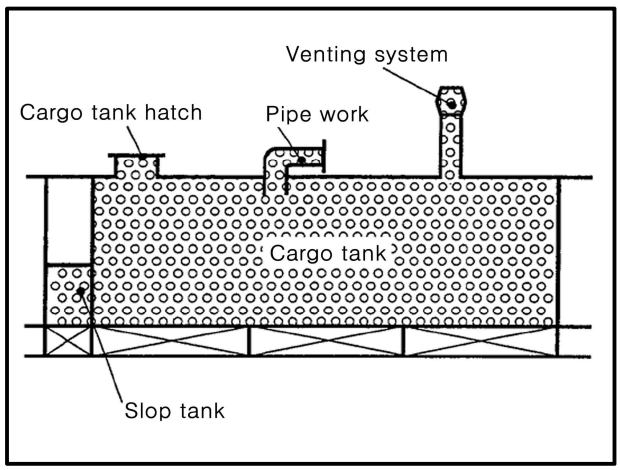


Fig 7.1.34 Example of (1) (A) zone 0

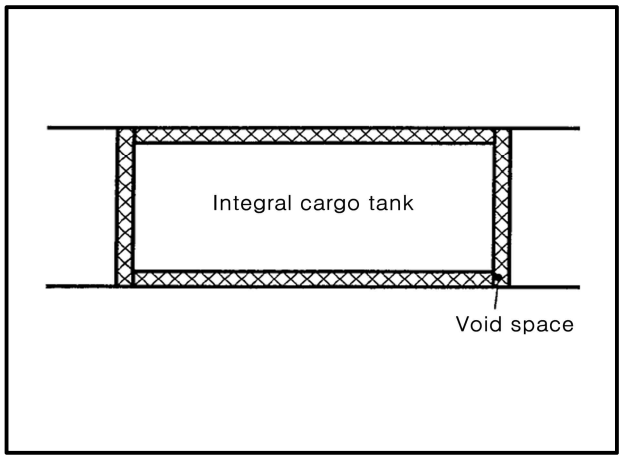


Fig 7.1.35 Example of (1) (B) zone 1 (a)

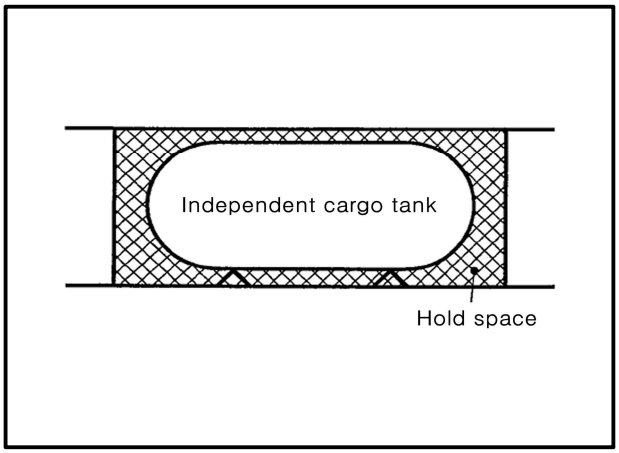


Fig 7.1.36 Example of (1) (B) zone 1 (b)

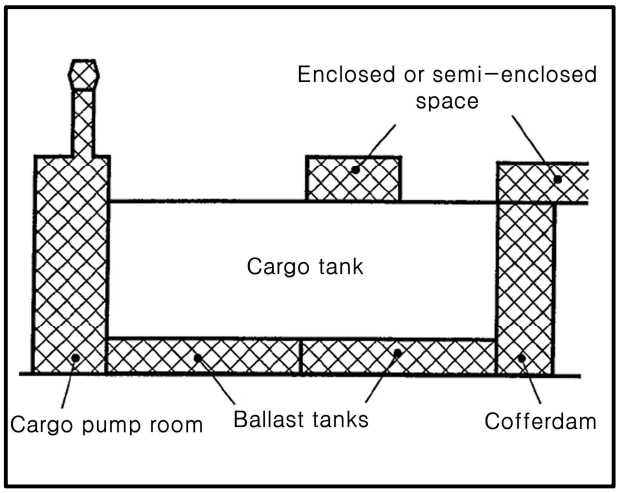


Fig 7.1.37 Example of (1) (B) zone 1 (c) ~ (f)

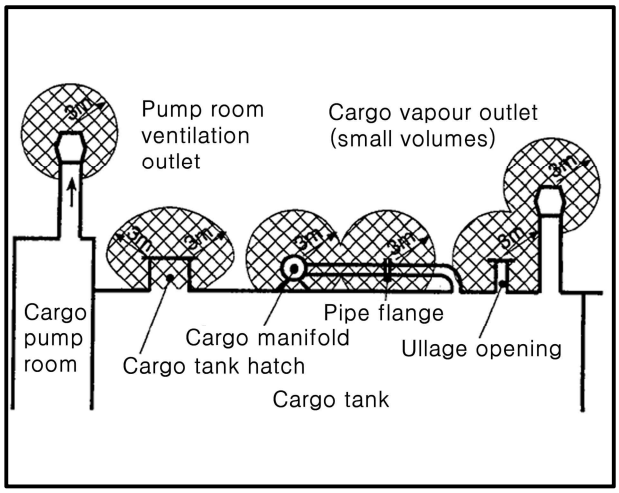


Fig 7.1.38 Example of (1) (B) zone 1 (g)

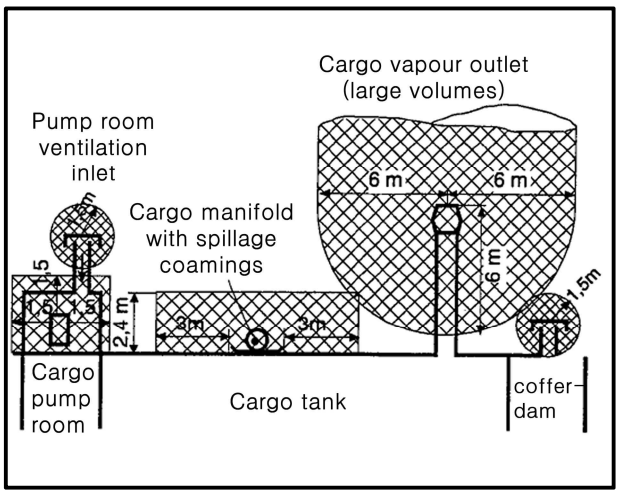


Fig 7.1.39 Example of (1) (B) zone 1 (h) ~ (j)

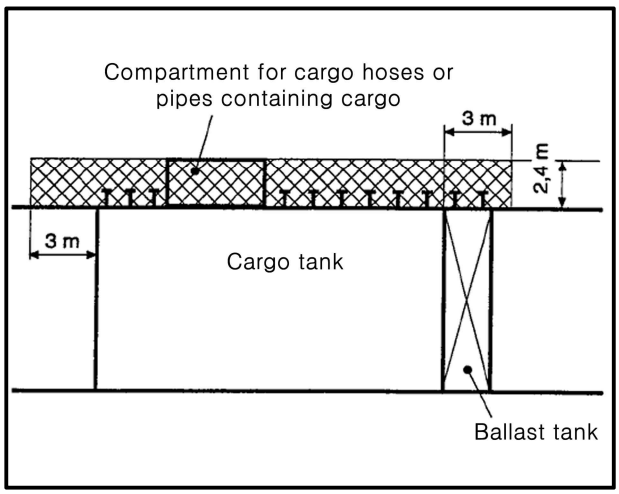


Fig 7.1.40 Example of (1) (B) zone 1 (k) ~ (m)

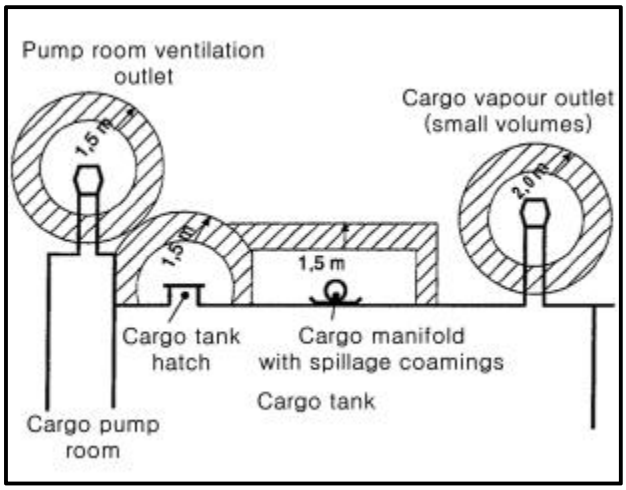


Fig 7.1.41 Example of (1) (C) zone 2 (a)

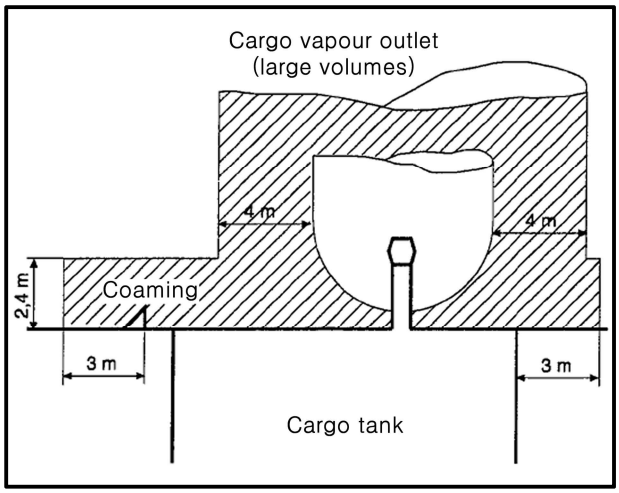


Fig 7.1.42 Example of (1) (C) zone 2 (b),(d),(e)

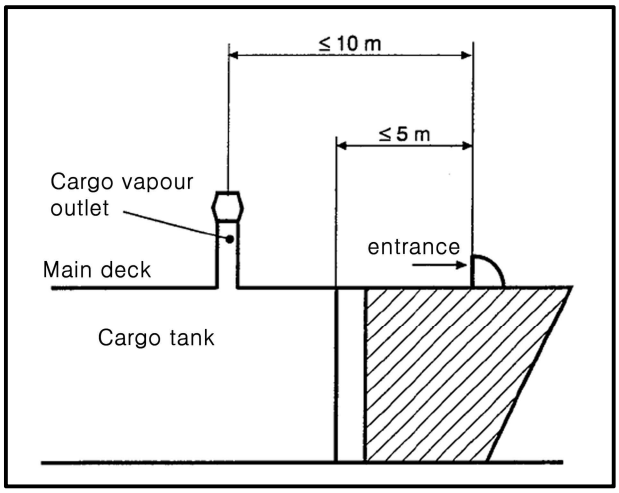


Fig 7.1.43 Example of (1) (C) zone 2 (f)

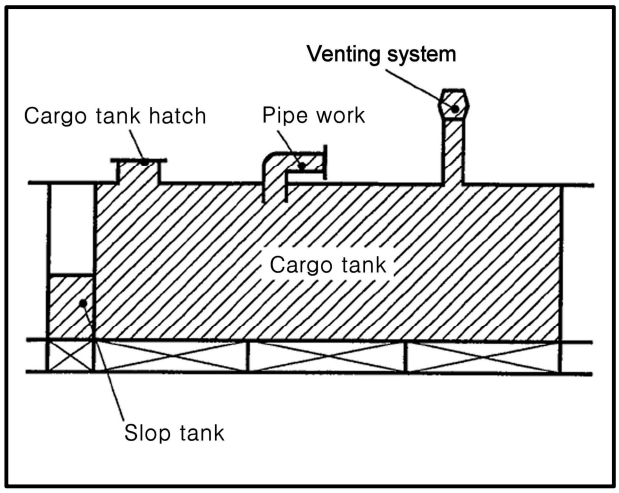


Fig 7.1.44 Example of (2) (B) zone 2 (a) ~ (d)

1103. Electrical equipment in dangerous spaces 【See Rule】

1. Explosion-protected electrical equipment in dangerous spaces is to be suitable for use in the explosion gas atmosphere classified into gases and vapours group IIB and temperature class T3 as specified in (KS C) IEC 60079, or equivalent thereto.

2. In addition to the requirements of **1103. 3** of the Rules following requirements are to be satisfied.

(1) In application of (2) and (3), cargo tank includes tanks adjacent to cargo tanks.

(2) The height of the anode is to be measured from the bottom of the tank to the center of the anode, and its weight is to be taken as the weight of the anode as fitted, including the fitting devices and inserts. However, where aluminum anodes are located on horizontal surfaces such as bulkhead girders and stringers not less than 1 m wide fitted with an upstanding flange or face flat projecting not less than 75 mm above the horizontal surface, the height of the anode may be measured from this surface.

1104. Earthing and bonding of cargo tanks, process plant and piping systems for the control of static electricity 【See Rule】

1. In application to **1104. 1, 2** of the Rules, where bonding straps are not provided, resistance tests are to be carried out and confirmed that each resistance for the related places is not greater than 1 MΩ. ⚓

CHAPTER 2 ORE CARRIERS

Section 1 General

101. Application 【See Rule】

1. In case of the ships have no experience the structural analysis of fore/aft body is in accordance with **103.** and **104.**

2. The special feature notation GRAB [X] is assigned, in accordance with maximum specific weight up to [X] tons of grab which is used during strength review of **Ch 2**.

3. In application to **101. 4** of the Rules, the term "deemed appropriate by the Society" means to comply with the direct strength calculation specified in **Pt 3, Ch 1, 206.** of the Rules, or to accept in accordance with **Pt 1, Ch 1, 105.** of the Rules.

Section 3 Wing Tanks or Void Spaces

304. Girder 【See Rule】

1. In tanks and spaces other than water ballast tanks, the thickness of transverses and swash bulkheads may be reduced by 1.0 mm, except where the provisions of **301.** of the Rules, are to be applied.

2. Measurement of span l (l_0, l_1 and l_2) of transverses in wing tanks and void spaces

Where the web under consideration and the adjacent web do not cross at a right angle to each other, l is to be as specified in **Fig 7.2.13.**

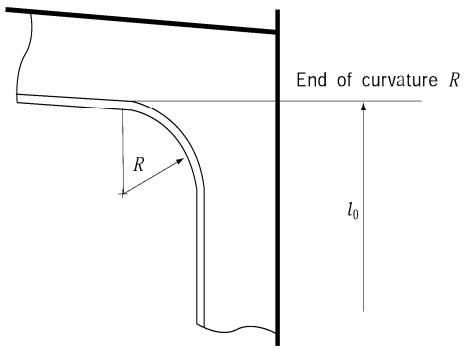
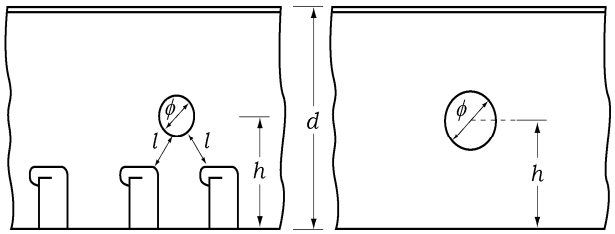


Fig 7.2.13 Measurement of l

3. The structural details of transverses and struts are to be in accordance with the following (1) to (3):

(1) General

(A) The dimensions and locations of lightening holes, where provided, are to be as shown in Fig **7.2.14**.



$$\phi \leq \frac{d}{4} \qquad \phi \leq \frac{d}{3}$$
$$h \leq \frac{d}{2} \qquad h \leq \frac{d}{2}$$
$$l \geq \phi$$

Fig 7.2.14 Locations and Dimensions of Lightening Holes

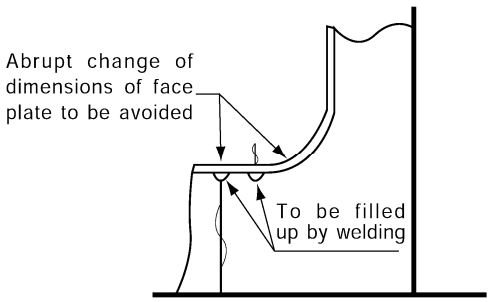


Fig 7.2.15

(B) Slots are to be reinforced with collars where flanges of longitudinals are facing each other or where slots are provided at small intervals as is often the case with bilge part.
(C) Where the depth of a girder is smaller than the required depth, its section modulus is to be obtained through multiplying the required section modulus by the ratio of required depth to the actual depth.
(D) In pump rooms or void spaces, the web thickness may be 1 mm smaller than the required thickness for webs in cargo oil tanks.
(E) Connection of web plates is to be of butt-welding. If lap-welding is adopted, stiffeners are to be provided across the connection lines.
(F) In end bracket parts, at connections with cross ties, etc. of transverses where sharing stress and/or compressive stress are expected to be high, additional stiffeners are to be fitted. These parts are not to have lightening holes. If considered necessary, slots for penetration of longitudinals in these parts are to be reinforced with collars. Sufficient consideration is to be taken for continuity of strength at the connection between struts and longitudinal (for example, soft brackets are to be provided on the both sides of transverse). (*2019*)
(G) No scallop is to be permitted in the web plate at the connections of face plates or webs. Inevitable scallops for work are to be filled up by welding. For face plates adjacent to the scallop, abrupt change of dimensions is to be avoided carefully. (See **Fig 7.2.15**)
(H) The radius of the rounded corner of longitudinals and transverses is to be as large as practicable.
(I) Where angle bars are used instead of flat bars as stiffeners of transverses, etc., their section modulus with effective plates is to be approximately equivalent to the required ones.
(J) Where longitudinal frames or stiffeners penetrate bottom transverses, side transverses and vertical webs on longitudinal bulkhead, proper reinforcement is to be made in the extents stipulated in **Table 7.2.9** by fitting brackets on the opposite side of stiffeners on webs of transverse, for connecting longitudinals to transverse, by fitting collars at slots, or by other

suitable means. In ships not exceeding 230 m in length, however, the extent of application of such reinforcement may be properly reduced. This reinforcement is to apply to the slots under conditions similar to those in the above-mentioned girders or transverses(for example, slots in transverse swash bulkheads, etc.)

Table 7.2.9 Extents of reinforcement

Member	Extent of reinforcement
Bottom transverse	All connections
Side transverse	All connections below the upper end of curvature of upper cross tie, or the load waterline, whichever is the higher. In ships of 300 m and above in length, it is recommended that similar reinforcement be applied in wider extent upward beyond the limit stipulated above.
Vertical webs on longitudinal bulkhead	All connections below the upper end of curvature of upper cross tie.

(2) The construction at the position of floors within the intersection of the inner bottom plating and longitudinal bulkhead is to comply with the following (A) and (B):
(A) Scallops at the above-mentioned intersections in transverses of wing tanks are to be filled up by welding or closed with collar plates. (See **Fig 7.2.16**)
(B) Transverses of wing tanks on the extended line of the inner bottom plating are to be fitted with gusset plates. (See **Fig 7.2.16**)

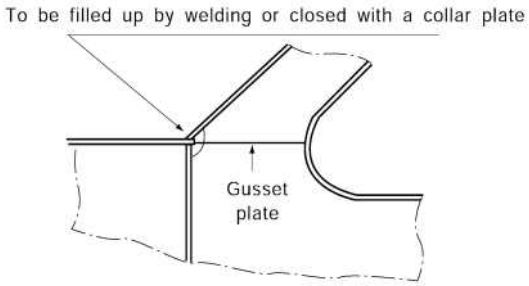


Fig 7.2.16

Section 5 Relative Deformation of Wing Tanks

501. Relative deformation of wing tanks 【See Rule】

1. Where the longitudinal bulkheads are inclined, a and b are to be so taken that the hatched areas may be same as shown in **Fig 7.2.17**.

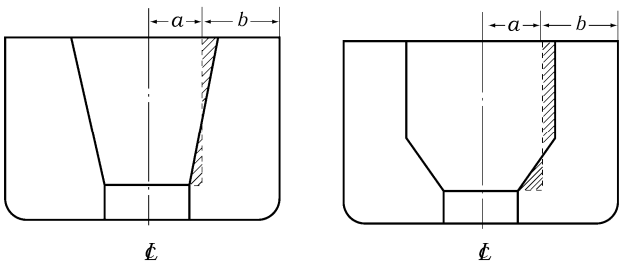


Fig 7.2.17

2. Special considerations for the case of exceeding limit values and how to measure mean thickness of transverse bulkhead plating are given in the following (1) and (2):

(1) Special considerations for the case of exceeding limit values
It is required to submit data enough to prove that the proposed construction has an equivalent effectiveness.

(2) Mean thickness in formulae
The mean thickness of plating in the formulae in **501.** of the Rules is to be obtained from the following formula.

$$t = \frac{\Sigma l_i t_i}{\Sigma l_i}$$

where :

l_i and t_i are to be taken as follows;

(A) Transverse bulkheads and perforated swash bulkheads : The thickness and breadth of each strake of the bulkhead are to be taken at the middle of the breadth of the tank as shown in **Fig 7.2.18.**

(B) Transverse rings and swash bulkheads of transverse ring type: The thickness and vertical extent of the deck transverse, transverse on longitudinal bulkhead between face bar of deck transverse and upper face bar of the uppermost strut and so on, and parts from the uppermost strut to the bottom transverse are to be taken at the middle of the breadth of the tank (at the bulkhead side if no plating is present at the middle of the breadth of the tank) as shown in **Fig 7.2.19.**

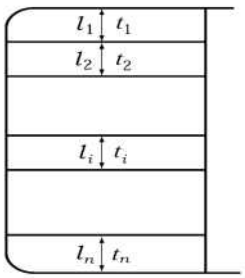


Fig 7.2.18

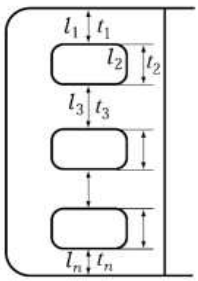


Fig 7.2.19

Section 7 Ore/Oil Carriers

701. General 【See Rule】

1. General

The construction, arrangement and equipment of ore/oil carriers are to be in accordance with the following, in addition to the provisions in **701. 2** of the Rules.

(1) The piping arrangement is to comply with **Par 3.**

(2) The length of combined ore holds/cargo oil tanks is to comply with **Pt 3, Ch 15, 103. 1.**

(3) Any openings which may be used for cargo operations are not to be fitted to bulkheads and decks separating the cargo oil tanks (including combined ore holds/cargo oil tanks) designed and equipped for the carriage of oil having a flash point below 60°C from other spaces not designed and equipped for the carriage of oil having a flash point below 60°C.

(4) When used as ore carrier, all compartments except slop tanks are to be gas-freed.

(5) As for the equipment, required time, etc. for cleaning and gas-freeing of cargo oil tanks, design documents are to be submitted to the Society for reference.

(6) At the time of approval of plans of ore/oil carriers, manuals containing precautions needed in the process of works for converting from oil tanker into ore carrier and vice versa are to be submitted to the owner and their copies submitted to the Society.

2. Construction of pump rooms

(1) The bottom of pump room of ore/oil carrier is to be constructed with particular care for the continuity of structural members.

(A) The longitudinal bulkheads in the hold space are to be extended aft as far as practicable. Deep horizontal girders are to be provided on the longitudinal bulkheads at the level of the inner bottom in the hold space. The webs of these girders are to be of approximately same thickness as the inner bottom.

(B) Centre girder
Height : same as double bottom in the hold space
Thickness : same as centre girder in the hold space

(C) Side girders
Number : if $b \leq 15$ m------ 2 lines each side,
if $b > 15$ m------ 3 lines each side,
Thickness : same as centre girder
Height : greater than double bottom height in engine room
It is recommended that the side girders be as high as possible.

(D) Sectional area of face plates of girders
The total sectional area of face plates of girders (including total sectional areas of horizontal girders on longitudinal bulkheads, if any) is not to be less than 35 % of the sectional area of inner bottom in the hold space.

(E) Bottom longitudinals
The section modulus of bottom longitudinals Z is to be 10 % times of that obtained from the formula in **Ch 1, 302** of the Rules. However, it is not to be less than that obtained from the following formula:

$$Z = 290\ d\ S \quad (\mathrm{cm}^3)$$

where :
d = draft (m)
S = space of longitudinal (m)

(F) Omission of side girders
One of side girders as per (C) above may be omitted, provided that the thickness of bottom shell plating under the pump room is increased by 2 mm in excess of the required thickness (including tapering).

(G) If high tensile steel is used for deck plating over the pump room, the sectional area of deck in this part is to be suitably increased in excess of the required area.

3. Piping systems

(1) Application
This requirements apply to piping systems and venting systems of ships designed to carry oil or alternatively solid cargoes in bulk.

(2) Terminology

(A) Combination carrier is a ore/oil carrier specified in **701. 1** of the Rule and a B/O carrier specified in **Ch 3, 801. 1** of the Rules.

(B) Slop tank is a tank which is provided mainly for the carriage of tank washings and cargo oil and which is designed to be capable of loading oil whose flash point does not exceed 60℃ when the ship is in the dry cargo mode.

(C) Solid cargo/oil hold is a compartment which is used as a solid cargo stowing hold when the ship is in the dry cargo mode and which is used as a cargo oil tank when the ship is not in the dry cargo mode.

(D) Ballast/solid cargo hold is a compartment which is used as an exclusive tank for ballast adjacent to a cargo oil tank when the ship is not in the dry cargo mode and which is used as a solid cargo stowing hold when the ship is in the dry cargo mode.

(E) Exclusive solid cargo hold is a compartment which is used as a void space adjacent to a cargo oil tank when the ship is not in the dry cargo mode and which is used as a solid cargo stowing hold when the ship is in the dry cargo mode.

(F) Oil/ballast tank is a tank which is used as a cargo oil tank when the ship is not in the dry cargo mode and which is used as a ballast tank or void space when the ship is in the dry

cargo mode.

(G) Exclusive ballast tank is a compartment which is adjacent to a cargo oil tank when the ship is not in the dry cargo mode and which is used as an exclusive tank for ballast even when the ship is in or not in the dry cargo mode.

(H) Cargo hold is a general term for solid cargo/oil hold, ballast/solid cargo hold and exclusive solid cargo hold.

(I) Cargo oil tank is a general term for solid cargo/oil hold, oil/ballast tank and slop tank.

(3) Bilge Piping Systems

(A) Bilge piping systems for the cargo holds are not to be led to the engine room. The cargo oil pump may be used for the purpose of bilge suction on condition that the cargo oil piping systems in the cargo oil pump room used for the bilge suction comply with the requirements in **Pt 5, Ch 6, 404.** and **405.** of the Rules.

(B) Bilge suction pipes for the cargo holds

(a) Where two or more cargo oil piping systems (e.g. main and stripping lines) are provided or cargo oil piping systems are provided independently for the oil/ballast tanks and cargo holds and where these cargo oil piping systems are so arranged that liquid in all or selected oil/ballast tanks and cargo holds can be discharged (for the oil/ballast tanks, include the filling of ballasting water) simultaneously when the ship is in the dry cargo mode, these cargo oil pipes may be used as the bilge suction pipes for cargo holds. The diameter of these cargo oil pipes used as bilge suction pipes is not to be less than that specified for the bilge suction pipes.

(b) Where bilge suction pipes are provided for the exclusive use, an exclusive pump for bilge suction is to be provided in the cargo oil pump room or the bilge suctions are to be connected to the cargo oil pump in the cargo oil pump room. Where cargo oil pumps are used as a bilge pump, a stop valve and a screw-down non-return valve are to be provided at the connection between the bilge pipe and cargo oil pump.

(C) Bilge suctions in cargo holds

(a) In general, one bilge suction is to be arranged on each side of the after end of the cargo hold. Where the length of cargo hold in ships having only one cargo hold exceeds 66 m, an additional bilge suction is to be arranged in a suitable position in the forward half-length of the hold.

(b) Bilge wells are to be arranged at suitable positions so as to protect the cover plates from the direct strike of solid cargoes, and to be provided with rose boxes or other suitable means so that the suction may not be choked by ore dust, etc.

(c) Bilge wells in solid cargo/oil holds and ballast/solid cargo holds, except where these bilge wells are also used as cargo oil suction wells, are to be provided with cover plates to blank off these wells or to be provided with blind flanges to blank off the open ends of the bilge suction pipes when the ship is not in the dry cargo mode.

(D) Bilge suction pipes

For exclusive bilge suction pipes, branch bilge suction pipes are to comply with the requirements in **Pt 5, Ch 6, Sec 4** in addition to the requirements in (C). In calculating the inside diameter of the branch bilge suction pipes for draining cargo hold bilge of ore/oil carriers, the mean width of cargo hold may be used in lieu of B. Bilge suction pipes which are also used as a cargo oil pipe or which are connected to eductors are to be as specified in **Table 7.2.10** in addition to comply with the requirements in (b) and ©.

Table 7.2.10 Bilge suction arrangement in cargo hold (common service piping or using eductor)

Type of cargo hold	Bilge suction main	Bilge suction branch	Bilge well	Provisions of valve, blind flange, etc.(3)
Solid cargo/oil hold	common service with cargo oil main	Exclusive	Exclusive	Screw-down non-return valve for branch line; blind flange for open end(1)
		Partial common service(2)	Exclusive(2)	Screw-down non-return valve and blind flange for bilge suction branch line
		Common service with cargo oil suction branch line	Common service with cargo oil suction well	Screw-down non-return valve for branch line
	use of eductor	—	Exclusive	Screw-down non-return valve for branch line; blind flange for open end
Ballast/solid cargo hold	common service with cargo oil main	Exclusive	Exclusive	Screw-down non-return valve for branch line; blind flange for open end
	use of eductor	—	—	Screw-down non-return valve for Suction side; blind flange for open end
Segregated solid cargo hold	common service with cargo oil main	Exclusive	Exclusive	Screw-down non-return valve for suction side; blind flange for open end
	use of eductor	—	Exclusive	Screw-down non-return valve for branch line

(Remark)
(1) Wells are to be closed with blind plates or open ends are to be closed with blind flange
(2) As specified in the example of **Fig 7.2.20.**
(3) Valves, in each case, are to be capable of being operated at control position above the bulkhead deck

(4) Cargo Oil Piping Systems
(A) Cargo oil piping systems, except for cargo oil pipes connected to the slop tanks specified in (5), are to be completely gas-freed when the ship is in the dry cargo mode.
(B) Cargo oil suctions in solid cargo/oil hold, except where these suctions are also used as bilge suctions, are to be provided with blank flanges to blank off the open end of the cargo oil suction pipes or to be provided with cover plates to blank off the cargo oil suction wells when the ship is in the dry cargo mode.
(C) Means are to be provided for isolating the piping connecting to the cargo oil pump room with the slop tanks where slop may be carried on dry cargo mode. The means of isolation are to consist of a valve followed by a spectacle flange or a spool piece with appropriate blank flanges. This arrangement is to be located adjacent to the slop tanks, but where this is unreasonable or impracticable it may be located within the pump room directly after the piping penetrates the bulkhead.(See **Fig 7.2.21**)
(D) A separate pumping and piping arrangement is to be provided for discharging the contents of the slop tanks directly over the open deck when the ship is in the dry cargo mode.
(E) Cargo oil lines below deck are to be installed inside the cargo wing tanks or to be placed in special ducts which are to be capable of being adequately cleaned and ventilated.

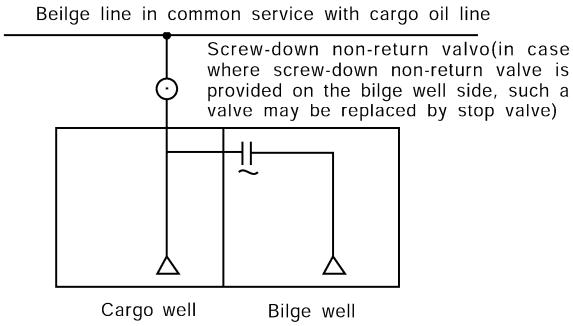


Fig 7.2.20 Examples of bilge suction arrangement in solid cargo/oil hold

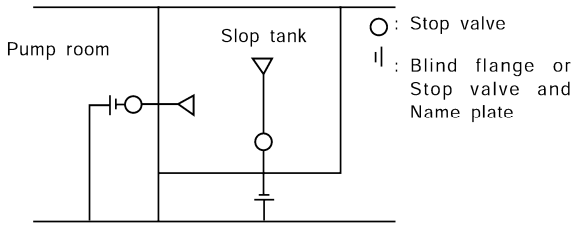


Fig 7.2.21 Examples of piping system of slop tank

(5) Ventilating systems

(A) Combination carriers which are not provided with slop tanks are to comply with the requirements in **Ch 1, 1004.** of the Rules for the ventilating systems for cargo oil tanks of oil tankers.

(B) Vent pipes for slop tanks are to be led to a suitable position in the open air so as to preclude any danger in case where oil having a flash point not exceeding 60°C is carried therein when the ship is in the dry cargo mode. Where vent pipes for slop tanks are connected to the vent pipes for the cargo oil tanks, a change-over device is to be provided to prevent the vapour in the slop tanks from entering into other compartments when the ship is in the dry cargo mode. This change-over device is in general to consist of a valve followed by a blank flange.

(C) All cargo spaces and any enclosed spaces adjacent to cargo spaces are to be capable of mechanically ventilated. The mechanical ventilation may be provided by portable fans.

CHAPTER 3 BULK CARRIERS

Section 1 General

101. Application 【See Rule】

1. The provisions of **Ch 3** of the Rules are to apply correspondingly to ships having structural configuration similar to bulk carriers such as chip carrier, log/timber carrier.

103. Direct strength calculation 【See Rule】

When determining the scantlings of structural members of cargo hold for a bulk carrier by direct strength calculations, the procedure is to comply with the **Pt 3, Annex 3-2 Guidance for Direct Strength Assessment** of the Guidance.

Section 3 Double Bottoms

301. General 【See Rule】

1. Value of k in the case of large slope angle of bilge hoppers or double-hull construction

Where the angle of slope of bilge hoppers to the horizontal exceeds 60° the value of k is to be obtained from the formula in **301. 4** of the Rules, assuming β = 60°. In ships with double-hull construction, the value of k may be 70 % of the value obtained from the same formula.

2. Measurement of hold length l_h

Where the angle of slope of lower stool of transverse bulkhead is smaller than 60° the hold length l_h in the formula in **301. 4** of the Rules, is to be the distance(m) between the intersections of the inner bottom and straight lines having a slope of 60° and passing through the top of the lower stool of the transverse bulkhead.

302. Centre girders and side girders 【See Rule】

1. In ships having unusually large freeboards, the height of centre girders may be reduced to the values obtained from the formula in **Table 7.3.2** of the Rules in which D is to be replaced by D', the depth to the assumed freeboard deck. In no case, however, is this height to be less than $B/20$.

2. Thickness of partial intermediate side girders

The thickness of partial intermediate side girders prescribed in **Table 7.3.2** of the Rules is not to be less than that obtained from the following (1) or (2), whichever is greater.

(1) Minimum thickness as specified in **106.** of the Rules

(2) $t = \dfrac{C_1'' d_2}{1000} + 2.5 \quad (\mathrm{mm})$

where:
d_2 = as specified in **Table 7.3.2** of the Rules.
C_1'' = as specified in **Table 7.3.1**
S_1 = as specified in **Table 7.3.2** of the Rules.

3. The "specially short holds" in **Table 7.3.2** and **304. 1** of the Rules are holds having a length equal to or less than 30 % of the length of adjacent holds.

4. When calculating the thickness of side girder just under the hopper plate of bilge hopper tank, S in the formula in **Table 7.3.2** of the Rules is to be measured, as a standard, as shown in Fig **7.3.1.** Further, when calculating the effective sectional area of the above-mentioned side girder, the sec-

tional area obtained from the following formula of the hopper plate in the extent shown in Fig **7.3.1** may be included into the effective sectional area of the same side girder.

$$A = 10\sum h_i t_i \left(1 - \frac{\theta}{90}\right) \quad (\mathrm{cm}^2)$$

where:

h_i = height in the hopper plate (m)

t_i = thickness of subtracted by the thickness 2.5 mm from the hopper plate (mm)

θ = angle between the side girder and the hopper plate (*degrees*)

Table 7.3.1 Coefficient C_1''

S_1/d_2	C_1''
upto 0.3	3.0
0.4	3.5
0.5	4.3
0.6	5.1
0.7	5.8
0.8	6.5
0.9	7.0
1.0	7.4
1.2	8.0
1.4	8.4
1.6 upward	8.6
Note: For intermediate value of S_1/d_2, C_1'' is obtained by linear interpolation.	

303. Floor plates 【See Rule】

1. Thickness of partial intermediate floors

(1) The thickness of partial intermediate floors prescribed in **Table 7.3.3** of the Rules is not to be less than that obtained from the following (1) or (2), whichever is greater:

(A) Minimum thickness as specified in **106.** of the Rules

(B) The thickness of neighbouring floors obtained from the formulae in **Table 7.3.3** of the Rules with the value of S reduced to 60 % of the actual one.

304. Inner bottom plating 【See Rule】

For the definition of "specially short holds," **302. 3** is to be referred to **304. 1** of the Rules.

305. Longitudinals 【See Rule】

For the applying **305** of the Rules, where the width of vertical stiffeners provided on floors and that of struts are specially large, the coefficient C *in* **Table 7.3.5** may be modifed in accordance with **Pt 3, Ch 7, 403. 2** of the Guidance.

Section 4 Hopper Tanks

401. General 【See Rule】

Floor plates are to be provided at the forward and after ends of hopper tanks, and the tank top plating in the engine room is to be keep the continuity of hopper tanks at ends extended into the hopper tanks by about 2 frame spaces.

402. Thickness of hopper plates 【See Rule】

1. Where the hopper plate has transverse stiffeners, the thickness of hopper plate is not to be less than that obtained from the following formula:

$$t = 9.6S + 1.5 \quad (\mathrm{mm})$$

where:

S = spacing of stiffeners (m)

The thickness of hopper plates to be included into the calculation of section modulus of hull girder is, but, to be the actual thickness multiplied by a factor of 0.5 when the ratio of the actual thickness to the thickness derived from the above formula is 1.0, or by a factor of 1.0 when the same ratio is 2.0 and above, or by a factor obtained by linear interpolation for an intermediate value of the ratio.

2. The construction at the intersection of inner bottom plating and hopper plate is to be as follows:

(1) The construction at the above-mentioned intersections is to be either of the following two types.

(A) The scallop in the hopper transverse at the above-mentioned intersection is to be filled up or closed by a collar plate. (See Fig **7.3.2**)

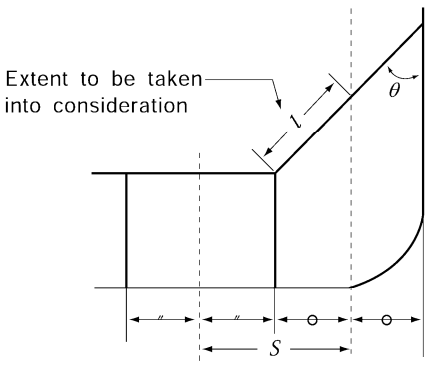


Fig 7.3.1 Measurement of S

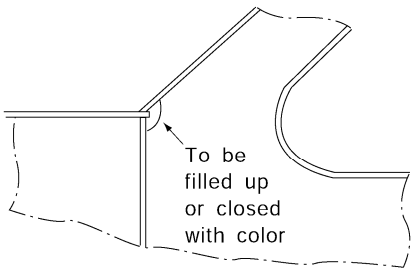


Fig. 7.3.2

(B) Gusset plates are to be fitted onto the hopper transverse in the extension of inner bottom plating. (See Fig **7.3.3**)

(2) Where the spacing of floor plates in 2 m or more, a bracket is to be provided at the mid-length between floor plates. This bracket is to reach the inner bottom longitudinal and the hopper plate longitudinal next to the side girder located at the intersection. (See Fig **7.3.4**)

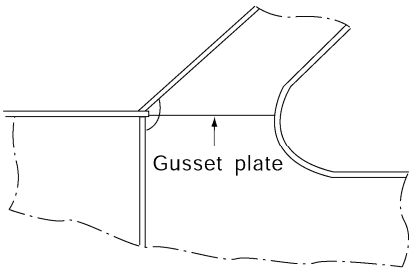


Fig. 7.3.3

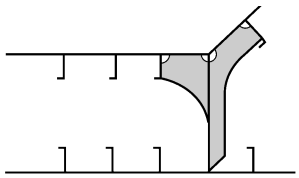


Fig. 7.3.4

Section 5 Topside Tanks

502. Thickness of sloping plates 【See Rule】

Where the sloping plate of topside tank has transverse stiffeners, the thickness of sloping plate is not to be less than that obtained from the following formula:

$$t = 12S + 1.5 \quad (\mathrm{mm})$$

where:

S = spacing of transverse stiffeners (m).

The thickness of sloping plates to be included into the calculation of section modulus of hull girder is, however, to be the actual thickness multiplied by a factor of 0.5 when the ratio of the actual thickness to the thickness derived from the above formula is 1.0, or by a factor 1.0 when the same ratio is 2.0 and above, or by a factor obtained by linear interpolation for an intermediate value of the ratio.

507. Large topside tanks 【See Rule】

Where the longitudinal diaphragm has transverse stiffeners, the thickness of diaphragm is not to be less than that obtained from the following formula:

$$t = 12.8S + 1.5 \quad (\mathrm{mm})$$

where:

S = spacing of transverse stiffeners (m)

The thickness of diaphragms to be included into the calculation of section modulus of hull girder is, however, to be the actual thickness multiplied by a factor of 0.5 when the ratio of actual thickness to the thickness derived from the above formula is 1.0, or by a factor 1.0 when the same ratio is 2.0 and above, or by a factor obtained by linear interpolation for an intermediate value of the ratio.

Section 6 Transverse Bulkhead and Stools

601. Transverse bulkhead 【See Rule】

For transverse bulkhead without lowest stool, the thickness of the lowest strake of bulkhead plating is to be 1 mm greater than those specified in formulae.

Section 7 Hold Frame

702. Top and bottom end connections of frames 【See Rule】

Figs. 7.3.5 and **7.3.6** show examples of connection of the upper and lower ends of hold frame to the topside tank and the bilge hopper tank respectively.

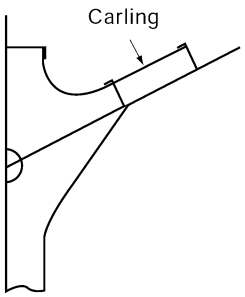


Fig 7.3.5

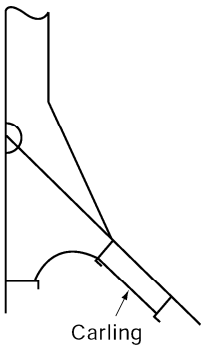


Fig 7.3.6

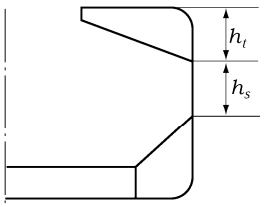


Fig. 7.3.7

Section 8 Decks and Shell Platings

801. Deck plating outside the line of openings 【See Rule】

The effective sectional area of deck outside the line of openings at the ends of topside tank is to be determined by tapering from the value obtained from the following formula:

$$A = \left(1 + \frac{A_t}{2A_d}\right) A_d$$

where:

A_t = effective sectional area of sloping plate of topside tank in the midship part

A_d = effective sectional area, required by the Rules, of the strength deck in the midship part

802. Deck plating inside the line of openings 【See Rule】

Where the deck inside the line of openings is constructed on the longitudinal framing system, the thickness of deck plating is not to be less than that obtained from the following formula:

$$t = 1.69\sqrt[3]{\frac{F}{l}S^2} + 1.5 \quad (\mathrm{mm})$$

where:

S = spacing of longitudinal beams (m)

l = length of deck inside the line of openings (m)

$$F = F_1 + F_2 \quad (\mathrm{kN})$$

$$F_1 = 0.49 h_t^2 (\alpha + 1)^2 (l_1 + l_2) \quad (\mathrm{kN})$$

$$F_2 = 0.26 LBC_b \quad (\mathrm{kN})$$

$$\alpha = \frac{h_s}{h_t}$$

h_t and h_s = vertical distance from the intersection of sloping plate of topside tank and side shell plating to the upper end of D(m) and vertical distance from the intersection of sloping plate of topside tank and side shell plating to the intersection of hopper plate of bilge hopper tank and side shell plating (m) (See Fig **7.3.7**)

l_1 and l_2 = lengths (m) of holds forward of and abaft the deck inside the line of openings concerned. But, the lengths of holds are defined as the distances between bulkheads.

Section 9 Hatch Covers and Hatch Coamings of Cargo Holds

905. Closing arrangements

1. Securing devices 【See Rule】

(1) When calculating the moment of inertia ($I = 6pa^4$) as specified in **905. 1** (7) of the Rules, the spacing between securing devices, a(m) is maximum of the distance between two consecutive devices, measured along hatch cover periphery(m), and not to be taken as less than 2.5 a_c.

Where,

a_c = max ($a_{1.1}$, $a_{1.2}$) (m) (Refer to **Fig 7.3.8**)

(2) When calculating the actual gross moment of inertia of the edge element, the effective breadth of the attached plating of the hatch cover is to be taken equal to the lesser of the following values.

(A) $0.165a$

(B) Half the distance between the edge element and the adjacent primary member

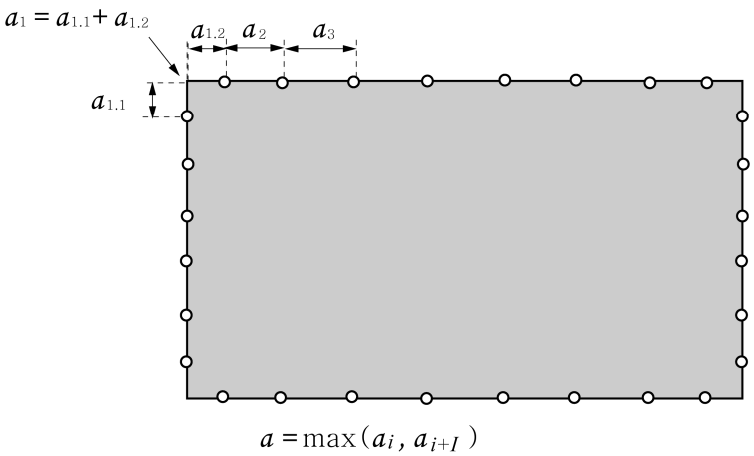
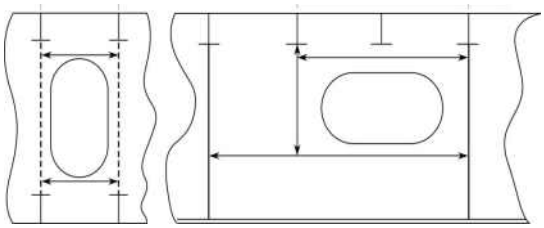


Fig 7.3.8 Spacing of securing devices

Section 11 Evaluation of Allowable Hold Loading for Bulk Carriers Considering Hold Flooding

1103. Shear capacity of the double bottom 【See Rule】

In application to **1103. 6** and **7** of the Rules, the term "Society's satisfaction" means reinforced by a ring stiffener or by additional panel stiffeners like below figure.



Section 14 Water Level Detection & Alarm and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships

1402. Application【See Rule】

In application to **1402. 2.** of the Rules, "suitable width" means that the distance between the side shell and the inner bulkhead in any part of the watertight compartments is not less than 760 mm measured perpendicular to the side shell.

Section 15 Supplementary Provisions for Carriage of Liquid in Holds

1501. General 【See Rule】

1. When cargo holds are utilized as ballast tanks, they are to be kept empty or full throughout the duration of voyage in order to avoid impact due to dynamical load of ballast water.

2. When cargo holds are utilized for ballasting, or under special loading conditions due to loading at two ports, etc., the scantlings of structural members of double bottoms are, in addition to compliance with the provision in **Sec 3.** of the Rules not to be less than that obtained from the formulae concerned which are modified as indicated below.

(1) Designed maximum load draught d is to replace with the draught in the considered loading condition d_b.

(2) The value of coefficient a in the formulae is to be equal to 0.45 + 0.026L'/d or the value obtained from either of the following two formulae depending on whether the hold is loaded or empty, whichever is greater.

For loaded hold : $a = h\gamma/d_b - (1 - 0.026L'/d_b)$

For hold which may be empty during navigation : $a = 1 + 0.026L'/d_b$

where:

γ = as specified in **301. 3** of the Rules

L' = as specified in **Table 7.3.2** of the Rules

(3) The value of coefficient n in the formulae prescribed in **Table 7.3.2** of the Rules is to be obtained from the following formula. But, the value of B/l_h in this formula is to be taken as 1.8 if it is not less than 1.8 and 0.5 if it is less than 0.5

$$n = \frac{1}{3}\left\{\alpha\left(2 - \frac{B}{l_h}\right) + 5 - \frac{B}{l_h}\right\}$$

where:

l_h = as specified in **301. 4** of the Rules

α = ratio of the load difference between the cargo load per unit area on the double bottom of the adjacent hold and the bottom water pressure including added variable wave pressure as prescribed in **Table 7.3.2** of the Rules to the similar load difference of the hold under consideration. The largest value of this ratio within the expected range of bottom water pressure is to be taken. α is to lie in the range from −1.0 to 1.0.

Table 7.3.2 Value of h

	h (m)
Pitching	$h = h_1 + 0.1\,l + 0.77\dfrac{h_1}{h_2}\left(1 - \dfrac{h_1}{h_2}\right)$
Rolling	$h = 0.4B\left\{\dfrac{3\times\dfrac{h_1}{h_2}+0.6}{\sqrt{\left\{1-\left(\dfrac{x}{l_s}\right)^2\right\}^2+\left\{17\left(\dfrac{h_1}{h_2}-0.45\right)^2+0.12\right\}\left(\dfrac{x}{l_s}\right)^2}} - 9.69\left(0.7-\dfrac{h_1}{h_2}\right)\left(0.3-\dfrac{h_1}{h_2}\right)\right\}$

h_1 = height of cargo oil level measured from the top of inner bottom (m)
h_2 = height of upper deck, at centreline, above the top of inner bottom(m)
l = length of hold (distance between transverse bulkheads)
l_s = vertical distance from the intersection of side shell with hopper plate of bilge hopper tank to the intersection of side shell with the sloping plate of topside tank (m)
x = vertical distance from the intersection of side shell with hopper plate of bilge hopper tank to the member under consideration (m)

1502. Holds half-loaded with cargo oils 【See Rule】

Where synchronism between pitching and/or rolling and the natural oscillations of cargo oil half-loaded in a hold is unavoidable, the scantlings of plating, stiffeners and girders, near the synchronizing oil level, of the transverse bulkheads in case of pitching or of the sloping plates of topside tanks in case of rolling are not to be less than that obtained from the respective formulae in which h is to be determined by the **Table 7.3.2.**

Section 16 Electrical Equipment in Coal Carriers

1603. Electrical equipment 【See Rule】

1. The wording "explosion-protected type as deemed appropriate by the Society" in **1603. 1** (2) of the Rules means those generally meeting the requirements in **Pt 6, Ch 1, Sec 9** of the Rules having the flash point G4, the explosion-protective construction of the explosion grade d1 over (Group II A, Temperature Class T4 as specified in (KS C) IEC 60079) or equivalent the explosion-proof construction, intrinsic safety pressurized protected construction which are serviceable safely in coal dust.
2. Cables led to electrical equipment installed within cargo holds are to be generally mineral insulated copper sheathed cables, lead sheathed armoured cables or non-metal sheathed armoured cables.
3. To the explosion-protected type approved by the Society in electrical equipment in compartments adjoining cargo holds specified in **1602. 1** (1) of the Rules the requirements in **1602. 1** above apply correspondingly.
4. In application to **1603. 3** of the Rules, the term "accepted by the Society" means to comply with the requirements of **Pt 6, Ch 1, Sec. 9** of the Rules and (KS C) IEC 60079 series.

Section 17 Renewal Criteria for Side Shell Frames and Brackets in Single Side Skin Bulk Carriers and Single Side Skin OBO Carriers

1701. Application and definitions

In application to **1701. 9** of the Rules, where the finite element or other numerical analysis or direct calculation procedure are allowed according to the Rules, i.e. in case of unusual side structure arrangements or framing, the analysis criteria and the strength check criteria are to be determined at the discretion of the Society. **【See Rule】**

1702. Renewal or other measures 【See Rule】

1. Lower end bracket flanges

The requirements in **1702. 1** (2) (A) (a) of the Rules specify that lower end bracket are required to be fitted and are to be provided with flanges. Bracket flanges are to be fitted on lower end brackets also in the following cases:

(1) When end brackets were not fitted with flanges at design stage and are required to be fitted according to the Rules. In this case, care is to be paid to ensure adequate back-up structure in the hopper and that the bracket is aligned with the back-up structure.

(2) When non-integral lower end brackets were not fitted with flanges at the design stage. In this case, flanges are to be fitted so as to meet the bending strength requirements in **1703. 4** of the Rules. The full width of the bracket flange is to extend up beyond the point at which the frame flange reaches full width.

2. t_M less than $t_{REN,d/t}$ at section b) of the frame

For the comparison with $t_{REN,d/t}$ at section b), the measured value, t_M , is to be based on zone B according to **Table 7.3.23** of the Rules.

3. Tripping brackets

(1) Where there are two existing tripping brackets supporting frames but their location is not in complete compliance with the Rules, i.e. one located less than h/3 above zone A and one less than 2h/3 from intersection of the hopper plate with the side shell, this may be accepted as equivalent to the requirements in **1702.** of the Rules, provided that the tripping bracket thickness is not less than the frame web thickness.

(2) Tripping brackets not connected to flanges are accepted for the purposes of the Rules, provided that have soft toe and the distance between the bracket toe and the frame flange is not greater than about 50 mm. (See **Fig 7.3.9**)

4. Bending check

The bending check needs not be carried out in the case the bracket geometry is modified so as to comply with **Sec 7.**

5. Blast cleaning and coating

When renewal is to be carried out according to the Rules, surface preparation and coating are required for the renewed structures for cargo holds of new buildings.

6. Zone B made of different plate thickness

When zone B is made up of different plate thickness, the lesser thickness is to be used for the application of the requirements in the Rules.

7. Repair of damaged frames already complying with the Rules.

In case of renewal of a damaged frame already complying with the Rules, the following requirements apply:

(1) The conditions accepted in compliance with the Rules are to be restored as a minimum.

(2) For localized damages, the extension of the renewal is to be carried out according to the standard practice of the Society, as the frame already complies with the Rules.

(3) Replacements of rolled profile are preferably to be made of the same rolled section. Built-up profiles are allowed in exceptional cases only. A repair made of an inserted built-up profile in a

rolled profile could be acceptable provided some precautions are taken. The flange of the built-up profile is to overlap the repair area with sniped shape to smoothly allow the stresses to pass from the rolled profile to the built-up profile and vice versa.

8. Repair of damaged frames before Ch 3, Sec 17 of the Rules implementation

In case of renewal of a damaged frame before implementation date of the Rules for the considered ship, as built scantlings may be applied. For practical reason, it is up to the Owner whether to renew according to the relevant Rules or not.

9. Tripping brackets for higher strength steel side frames and side shell

Where side frames and side shell are made of higher strength steel (HSS), normal strength steel (NSS) tripping brackets may be accepted, provided the electrodes used for welding are those required for the particular HSS grade, and the thickness of the tripping brackets is equal to the frame web thickness, regardless of the frame web material.

1703. Application of roll radius of gyration(k_r) and bending moment coefficient(m_a) 【See Rule】

The following loading conditions are to be considered for the application of the **Ch 3, Sec 17** of the Rules.

(1) Homogeneous heavy cargo (density greater than 1.78 $\mathrm{t/m^3}$), considering k_r=0.25B
(2) Homogeneous light cargo (density less than 1.78 $\mathrm{t/m^3}$), considering k_r=0.39B
(3) Non homogeneous heavy cargo, if allowed, considering k_r=0.39B
(4) Multi port loading/unloading conditions need not be considered.

Therefore, the following combination of roll radius of gyration(k_r) and bending moment coefficient (m_a) table apply for the purpose of the relevant Rules.

(1) Empty holds of ships allowed to operate in non homogeneous loading conditions, k_r=0.38B and m_a=10, m_b=17, 19 or 22
(2) Loaded holds of ships allowed to carry only light cargo(density less than 1.78 $\mathrm{t/m^3}$) k_r=0.38B and m_a=12, m_b=20, 22 or 26
(3) Other cases k_r=0.25B and m_a=12, m_b=20,22 or 26. This represents the loaded hold of a ship in homogeneous heavy cargo loading condition, which is more severe than a loaded hold in non homogeneous cargo condition, where k_r=0.39B.

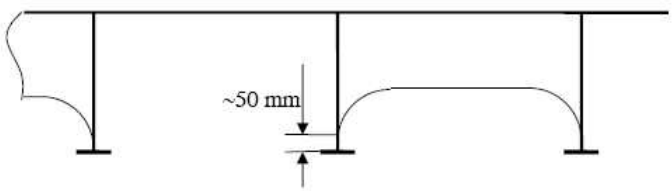


Fig 7.3.9 Tripping bracket

CHAPTER 4 CONTAINER SHIPS

Section 1 General

101. Application 【See Rule】

In application to **101. 4** of the Rules, the term "discretion of the Society" means to comply with the direct strength calculation specified in **Pt 3, Ch 1, 206.** of the Rules, or to accept in accordance with **Pt 1, Ch 1, 105.** of the Rules.

Section 2 Longitudinal Strength

205. Torsional strength 【See Rule】

The torsional strength of hull at each sectional position from the collision bulkhead to the watertight bulkhead at the fore end of the machinery space is to be such that the following relationship is satisfied.

$$\sqrt{(0.75\sigma_V)^2+\sigma_H^2+\sigma_W^2}+|\sigma_S| \leq 175/K$$

where:

σ_S = the longitudinal bending stress by the longitudinal bending moment in still water as obtained from the following formula

$$\sigma_S = M_S/Z_V \times 1000 \quad (\mathrm{N/mm^2})$$

σ_V = the longitudinal bending stress by the longitudinal bending moment in wave as obtained from the following formula

$$\sigma_V = M_W/Z_V \times 1000 \quad (\mathrm{N/mm^2})$$

σ_H = the horizontal bending stress by the horizontal bending moment in wave as obtained from the following formula

$$\sigma_H = M_H/Z_H \times 1000 \quad (\mathrm{N/mm^2})$$

M_S, M_W = as specified in **202.** of the Rules

M_H = the horizontal bending moment as obtained from the following formula:

$$M_H = 0.45 C_1 L^2 d(C_b+0.05) C_H \quad (\mathrm{kN\text{-}m})$$

C_H = coefficient as given in **Table 7.4.1** whose value depends on the ratio of the distance X (m) from the aft end of L to the position of the section under consideration, where intermediate values are to be determined by interpolation.

Table 7.4.1 Coefficient C_H

X/L	0.0	0.4	0.7	1.0
C_H	0.0	1.0	1.0	0.0

Z_V = section modulus of strength deck with respect to longitudinal bending of hull at the position of the section under consideration (cm^3).

Z_H = section modulus of hatch side with respect to horizontal bending of hull at the position of the section under consideration (cm^3).

C_1 = as specified in **Pt 3, Ch 3, Table 3.3.1** of the Rules

sW = warping stress due to bending torsion of hull, which is are to be in accordance with the discretion of the Society. But, the value of bending torsion of hull is calculated according to the following formula

$$M_T = \frac{M_0}{2}\left(1-\cos\frac{2\pi}{L}X\right) \quad (\mathrm{kN\text{-}m})$$

$$M_0 = 7.0K_2C_W^2B^3\left(1.75+1.5\frac{e}{D_S}\right) \quad (\mathrm{kN\text{-}m})$$

C_W= water plane area coefficient.

e = the distance from the top of keel to the shear centre (m). For which is in the below of top of keel, e is taken as positive and it may given by the following formula.

$$e = e_1 - \frac{d_0}{2}$$

e_1 : as given by the following formula.

$$e_1 = \frac{(3D_1-d_1)d_1t_d + (D_1-d_1)^2t_s}{3d_1t_d + 2(D_1-d_1)t_s + B_1t_b/3}$$

d_0 : height of double bottom(m)

d_1 : breadth of double hull side(m)

D_1 : as given by the following formula.

$$D_1 = D_S - \frac{d_0}{2}$$

B_1 : as given by the following formula.

$$B_1 = B - d_1$$

t_d, t_s, t_b : mean thickness(m) of deck, ship's side, and bottom specified in **Fig 7.4.1.** Mean thickness may be determined including all the longitudinal strength members within this range.

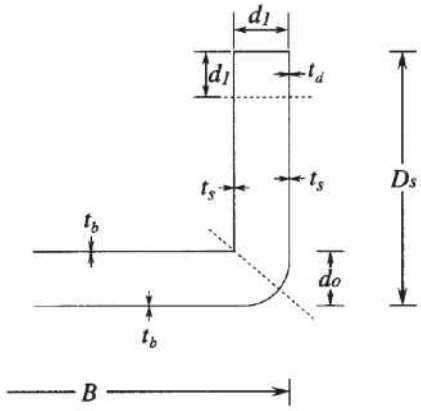


Fig 7.4.1

K_2 = as given by the following formula:

$$L < 300\,m \ : \ K_2 = \sqrt{1-\left(\frac{300-L}{300}\right)^2}$$
$$L \geq 300\,m \ : \ K_2 = 1.0$$

X = distance from the aft end to considering section (m)

Section 3 Double Bottom Construction

302. Longitudinals 【See Rule】

Where the widths of vertical stiffeners on floor plates and vertical struts are specially large, the coefficient C prescribed in **Table 7.4.1** of the Rules may be modified as prescribed in **Pt 3, Ch 7, 403. 2.**

Section 4 Double Side Construction

401. General 【See Rule】

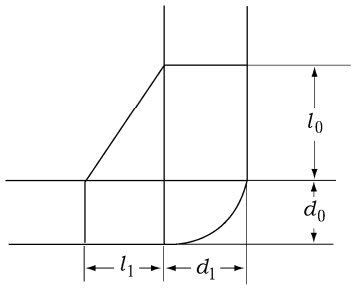
1. Where the breadth of double side construction varies in the bilge part, t_1 in **Table 7.4.2** of the Rules is to be determined as follows:

(1) β_T and β_L are to be obtained from the following formulae:

$$\beta_T = 1 + \frac{0.42\left(\frac{B}{D_S}\right)^2 - 0.5}{0.59\frac{D_S - \frac{d_0}{2} - l_{OR}}{B - d_1 - 2l_{1R}}\left(\frac{d_0}{d_1}\right)^2 + 1.0}, \qquad \beta_L = 1 + \frac{0.18\left(\frac{B}{D_S}\right)^2 - 0.5}{0.59\frac{D_S - \frac{d_0}{2} - l_{OR}}{B - d_1 - 2l_{1R}}\left(\frac{d_0}{d_1}\right)^2 + 1.0}$$

l_{OR} and l_{1R} are to be obtained as follows:

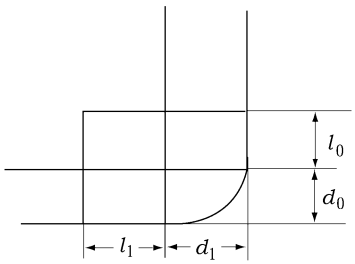
(a) Bilge hopper type (See **Fig 7.4.2**)
(b) Stepped type (See **Fig 7.4.3**)



$$l_{OR} = \frac{l_0 l_1}{d_1 + l_1}$$

$$l_{1R} = \frac{l_0 l_1}{d_0 + l_0}$$

Fig 7.4.2



$l_{OR} = l_O$
$l_{1R} = l_1$

Fig 7.4.3

(2) The lower end of h is to be a point at a height of l_{OR} above the inner bottom.
(3) $(d-l_{OR}+0.038L')$ is to be substituted for $(d+0.038L')$.

2. Where the height from the designed maximum load line to the strength deck is usually large, t_1 as per **Table 7.4.2** is to be calculated as follows

(1) β_T and β_L are to be obtained from the following formulae:

$$\beta_T = 1 + \frac{0.42\dfrac{B^2}{D_S D'} - 0.5}{0.59\dfrac{D_S - \dfrac{d_0}{2}}{B - d_1}\left(\dfrac{d_0}{d_1}\right)^2 + 1.0}, \qquad \beta_L = 1 + \frac{0.18\dfrac{B^2}{D_S D'} - 0.5}{0.59\dfrac{D_S - \dfrac{d_0}{2}}{B - d_1}\left(\dfrac{d_0}{d_1}\right)^2 + 1.0}$$

where :

D' = depth of the ship (m), where the imaginary freeboard deck is provided according to **Pt 3, Ch 1, 203. 2.** (1). D' may be the height from the top of keel to this assumed deck (m).

(2) The value obtained from the following formula is to be substituted for $(d+0.038L')$

$$(d+0.038L')\sqrt{\frac{D'}{D_S}}$$

where :

D' = as specified in (1).

3. If there is a combination of a cross-tie having an ample sectional area and non-watertight partial bulkhead or any similar construction is provided midway in the hold, the l_h in provisions in **Table 7.4.2** may be measured from the bulkhead to such a construction.

4. In case where the breadth of angles or flat bars supporting stiffeners in double hull of side construction is unusually large, scantlings of stiffeners may be determined in accordance with the provision of **Pt 3, Ch 7, 403. 2.**

402. Side transverse and side stringer 【See Rule】

The thickness of side transverse girders for shear force and shear buckling strength is not to be less than that obtained from the **Table 7.4.2** in addition to the requirement of Rules, whichever is greatest.

Table 7.4.2 The thickness of side transverse and side stringer

Division	Thickness (mm)
Side transverse and Side stringer	$t_1 = 0.083\frac{CSl_h}{d_1 - a}(d + 0.038L') + 1.5, \quad t_2 = 8.6\sqrt[3]{\frac{d_1^2(t_1 - 1.5)}{k}} + 1.5$

C : as specified in the following Table.

Side transverse

$$C = (C_1 + \beta_T C_2) C_3$$

$$\beta_T = 1 + \frac{0.42\left(\frac{B}{D_S}\right)^2 - 0.5}{0.59\frac{\left(D_S - \frac{d_0}{2}\right)}{(B - d_1)}\left(\frac{d_0}{d_1}\right)^2 + 1.0}$$

C_1, C_2 = as obtained from the following table, in accordance with the value of h/l_h. For intermediate values of h/l_h, the values of C_1 and C_2 are to be determined by linear interpolation.

h/l_h	C_1	C_2
0.5 and under	0.18	0.05
0.75	0.21	0.08
1.00	0.24	0.09
1.25	0.25	0.10
1.50	0.26	0.11
1.75 and above	0.27	0.12

C_3 = as obtained from the following formula, but not to be less than 0.2.

$$C_3 = 1 - 1.8\frac{y}{h}$$

Side stringer

$$C = (C_1 - \beta_L C_2) C_3$$

$$\beta_L = 1 + \frac{0.42\left(\frac{B}{D_S}\right)^2 - 0.5}{0.59\frac{\left(D_S - \frac{d_0}{2}\right)}{(B - d_1)}\left(\frac{d_0}{d_1}\right)^2 + 1.0}$$

C_1, C_2 = as obtained from the following table, in accordance with the value of h/l_h. For intermediate values of h/l_h, the values of C_1 and C_2 are to be determined by linear interpolation.

h/l_h	C_1	C_2
0.5 and under	0.20	0.07
0.75	0.24	0.05
1.00	0.26	0.03
1.25		0.01
1.50 and above		0.00

C_3 = as obtained from the following formula

$$C_3 = \left|1 - \frac{2x}{l_h}\right|$$

h = vertical distance from the top of inner bottom to the strength deck at side(m)
l_h = length of hold(m)
d_0 = height of centre girder(m)
L' = length of ship(m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
d_1 = depth of side transverse or side stringer(m). where, the depth of webs is divided by providing stiffeners in the direction of the length of girder on the webs, d_1 in the formulae for t_2 may be taken as the divided depth.
S = width of the area supported by the side transverse girders(m)
a = depth of the openings at the location under consideration(m)
S_2 = S_1 or d_1, whichever is smaller
y = distance from the lower end of h to the location under consideration(m)
x = distance from the end of l_h to the location under consideration(m)
k = coefficient obtained from table in accordance with the ratio of the spacing S_1 (m) of the stiffeners provided in the direction of the depth of girder on the web of side transverse girder and d_1. For intermediate values of S_1/d_1, the value of k is to be determined by linear interpolation.

S_1/d_1	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0 and above
k	60	40	26.8	20	16.4	14.4	13.0	12.3	11.1	10.2

Section 6 Deck Construction

601. Construction 【See Rule】

The requirements of decks inside the line of deck openings in connection with bending in the plane of deck are not to be less than that obtained from the **Table 7.4.3.** In the calculations of section modulus and moment of inertia, the deck inside the line of deck openings is to be regarded as a web and the hatch end coaming as a flange.

Table 7.4.3 Decks inside the line of deck opening

Item	Framing	Scantling
Thickness of deck	Boxshaped construction	$t = 0.00417 C_1 K \left(\frac{l_V^2 l_C}{\omega_C} \right) + 4.0 \quad (\mathrm{mm})$ But, it is to be included the thickness of bottom plating.
	Others	$t = 0.00417 C_1 K \left(\frac{l_V^2 l_C}{\omega_C} \right) + 1.5 \quad (\mathrm{mm})$
Section modulus	$Z = 1.43 C_2 K l_V^2 l_C^2 \quad (\mathrm{cm}^3)$	
Moment of inertial	$I = 0.38 \frac{l_C^4}{S l_V^3} I_V \quad (\mathrm{cm}^4)$	

l_V = distance from the top of inner bottom plating to the bulkhead deck at the centre line of ship (m)
l_C = width of hatchway(m). where two or more rows of hatchway are provided, the width of the widest hatchway is to be taken.
ω_C = width of deck inside the line of deck openings(m)
C_1, C_2 = as obtained form Table in accordance with the value of α. For intermediate values of α, the value of C1, C2 are to be determined by linear interpolation.

α	C_1	C_2
0.5 and under	1.00	0.50
1.5 and above	0.37	0.10

α = as obtained form the following formula

$$\alpha = 0.5 l_C \sqrt[4]{\frac{3}{4 S l_V^3} \times \frac{I_V}{I_C}}$$

S = spacing of vertical webs provided on transverse bulkhead (m)
I_V = moment of inertia vertical webs provided on transverse bulkhead (cm^4)
I_C = moment of inertia of decks inside the line of deck openings (cm^4)

Section 9 Strength at Large Flare Location *(2019)*

901. Shell plating 【See Rule】

The thickness of shell plating is to be in accordance with **Pt 3, Ch 4, 401.1.**

902. Frames 【See Rule】

The scantlings of frames are to be in accordance with **Pt 3, Ch 8, 108.1.**

903. Girders 【See Rule】

1. The scantlings of girders are to be in accordance with **Pt 3, Ch 9, 104.1.**
2. Buckling strength of girders webs are to be examined by the requirements in **Pt 3, Ch 9, 104.2., 3.**

Section 10 Freight Container Securing Arrangement

1002. Freight container securing systems 【See Rule】

1. In case of intending to be approved by the Society for freight container securing arrangement as specified in **1002.** of the Rules, it is to be satisfied with the requirement of **Annex 7-2 Guidance for the Container Securing Arrangements.**
2. For approval of manufacturing process and type approval of securing arrangement are to comply with the requirements in **Ch 3, Sec 25.** of 「**Guidance for Approval of Manufacturing Process and Type Approval, etc.**」
3. Inspection procedure of Freight container securing arrangement
   (1) Inspection procedure of type approved freight container securing arrangement in accordance with the requirements of **Ch 3, Sec 25** of 「**Guidance for Approval of Manufacturing Process and Type Approval, etc.**」 is as follows.
   (2) The nature and extent of production testing will be considered but the arrangements are to be at least equivalent to one of the following schemes:
      (A) (a) For rod lashings, fittings and securing devices
      One sample from every fifty pieces, or from each batch if less than fifty piece, is to be proof loaded to 1.5 times the safe working load for which the item is intended.
      (b) For chain or wire rope lashings
      One sample from every fifty pieces, or from each batch if less than fifty piece, is to be to breaking.
      (B) Alternatively, every piece of fittings, securing devices and lashings is to be proof loaded to the safe working load of the item and in addition, one sample from every batch of chain or wire rope lashings is to be tested to breaking.
   (3) For fixed securing devices such as items **11.** to **14.** in **Table 3.25.2** of 「**Guidance for Approval of Manufacturing Process and Type Approval, etc.**」 consideration will be given to a reduced frequency of mechanical production testing provided the following (A) and (B). Where manufacturer for the fixed securing devices has the certificates of this Class' quality assurance system, inspection procedure is to comply with **Ch 5, 305.** of 「**Guidance for Approval of Manufacturing Process and Type Approval, etc.**」
      (A) Prototype test results indicate a breaking strength at least 50 % greater than that required by the **Table 3.25.1** of 「**Guidance for Approval of Manufacturing Process and Type Approval, etc.**」
      (B) A suitable non-destructive inspection procedure is agreed.
   (4) For production tests carried out in accordance with (2)(A) permanent deformation(other than that due to initial embedding of component parts) will not be accepted within the range of loading up to :
      (A) where SWL is less than 25 *tones* : 1.5 × SWL (*ton*)
      (B) where SWL is 25 *tones* or greater : SWL + 12.5 (*ton*)
      Consideration may be given to acceptance of permanent deformation in the load range between that given in (2) and the proof load provided that satisfactory manual operation can be achieved after completion of tests.
   (5) In the event of premature failure or serious plastic deformation occurring in a test sample a further sample should be selected for testing. In the event that this sample is found to be unsatisfactory, the associated batch will be rejected.
   (6) For production tests carried out in accordance with (2)(B) permanent deformation will not be accepted.

CHAPTER 5 SHIPS CARRYING LIQUEFIED GASES IN BULK

(Separate Publication)

CHAPTER 6 SHIPS CARRYING DANGEROUS CHEMICALS IN BULK

(Separate Publication)

CHAPTER 7 CAR FERRIES AND ROLL-ON/ROLL-OFF SHIPS

Section 3 Deck Structure

301. Application 【See Rule】

1. Thickness of vehicle deck

The thickness of vehicle deck is to be less than that obtained from the following (1) and (2). *(2017)* However, the thickness of plating of weather decks is to be 1 mm thicker than obtained from those formulae.

(1) Where the distance between centres of wheel prints in a panel is not less than $2S+a$ (See **Fig 7.7.1**)

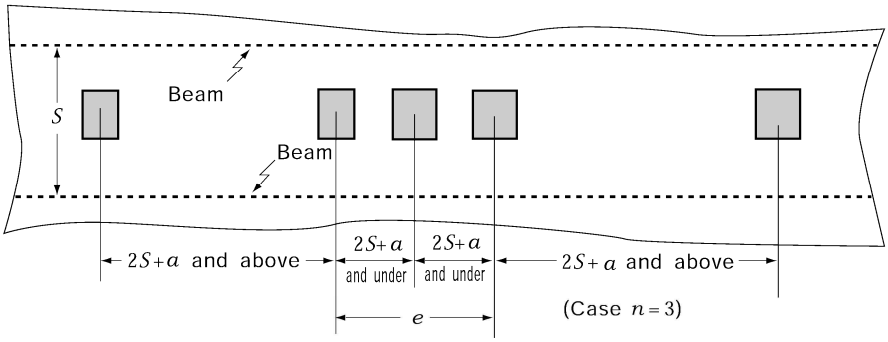


Fig 7.7.1 Measurement of e

$$t = C\sqrt{\frac{(2S-b')}{(2S+a)} \times \frac{P}{9.81}} + 0.5 \quad (\mathrm{mm})$$

C = coefficient determined as specified in **Table 7.7.1.**

S = beam spacing (m)

P = maximum design wheel load (kN). if $b > S$, a value equal to the maximum designed wheel load multiplied by the value of S/b

b' = b or S, whichever is the smaller (m)

a and b = length of wheel print measured in parallel and perpendicular to beam (See **Fig 7.7.2**). For vehicles with ordinary pneumatic tires, however, values of a and b in **Table 7.7.2** may be used.

Table 7.7.1 Coefficient C

Frames \ Vehicles		Vehicles used for cargo handling	Other vehicles
Midship part of strength deck	Longitudinal framing	$4.6\sqrt{K}$	$\frac{3.64\sqrt{K}}{\sqrt{1-0.64 f_D K}}$
	Transverse framing	$4.9\sqrt{K}$	$\frac{5.15\sqrt{K}}{\sqrt{1-0.41(f_D K)^2}}$
Elsewhere		$4.6\sqrt{K}$	$5.2\sqrt{K}$
f_D = as specified in **Pt 3, Ch 1, 124** of the Rules. In longitudinal framing system, it is to be $0.79/K$ or more.			

Table 7.7.2 Wheel print length a and b

Direction / Wheel	Wheel print length parallel to axle In **Fig 7.7.2,** a in Case (I), b in Case (II)	Wheel print length right angle to axle In **Fig 7.7.2,** a in Case (I), b in Case (II)
Single tire	Tire width	$\frac{1}{20}\sqrt{P}$
Double tire	2×tire width. Interval between tires, if any, may be added	$\frac{9}{250}\sqrt{P}$
P = as specified in **Par 301. 1 (1)**		

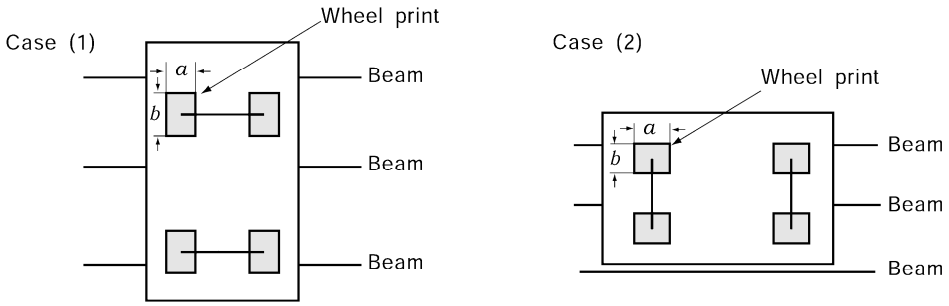


Fig 7.7.2 Measurement of a and b

(2) Where the distance between centres of wheel prints in a panel is less than $2S + a$ (See **Fig 7.7.1**) *(2017)*

$$t = C\sqrt{\frac{2S-b')}{(2S+a+e)} \times \frac{nP}{9.81}} + 0.5 \quad (\mathrm{mm})$$

e = sum of distances between centres of wheel prints in case where wheels are placed side by side at a spacing less than $2S+a\,(\mathrm{m})$ (See Fig **7.7.1**)

n = number of wheel loads in the range of e

C, S, a, b' and P = as specified in (1)

2. Section modulus of vehicle deck beams *(2017)*

The section modulus of beams of decks loaded with wheeled vehicles is not to be less than that obtained from the following formula:

$$Z = C_1 C_2 M \quad (\mathrm{cm}^3)$$

C_1 = coefficient determined as follows.

for $b/S \leq 0.8$: $C_1 = 1.0$
for $b/S > 0.8$: $C_1 = 1.25 - 0.31 b/S$

C_2 = coefficient determined from **Table 7.7.3**

Table 7.7.3 Coefficient C_2

Members \ Vehicles	Vehicles exclusively used for cargo handling	Other vehicles
Longitudinal beams of strength decks in midship region	$\frac{3.6K}{1-0.34f_D K}$	$\frac{4.6K}{1-0.64f_D K}$
Elsewhere	$3.6K$	$4.6K$
f_D = as specified in **Pt 3, Ch 1, 124.** of the Rules. But, it is to be less than $0.79/K$		

b, P and S = as specified in **Par 1** (1)
M = M_1 or M_2 obtained from the following formulae, whichever is greater.

$$M_1 = \frac{1}{9.81}\left(\sum_{i=1}^{N_I} 4P_{Ii}\alpha_{Ii}\left\{1-\left(\frac{\alpha_{Ii}}{l_I}\right)^2\right\} + \sum_{j=1}^{N_{II}} P_{IIj}\alpha_{IIj}\left(1-\frac{\alpha_{IIj}}{l_{II}}\right)\left(7-5\frac{\alpha_{IIj}}{l_{II}}\right) - \sum_{k=1}^{N_{III}} P_{IIIk}(l_{III}-\alpha_{IIIk})\left\{1-\left(\frac{l_{III}-\alpha_{IIIk}}{l_{III}}\right)^2\right\}\right)$$

$$M_2 = \frac{1}{9.81}\left(-\sum_{i=1}^{N_I} P_{Ii}\alpha_{Ii}\left\{1-\left(\frac{\alpha_{Ii}}{l_I}\right)^2\right\} + \sum_{j=1}^{N_{II}} P_{IIj}\alpha_{IIj}\left(1-\frac{\alpha_{IIj}}{l_{II}}\right)\left(2+5\frac{\alpha_{IIj}}{l_{II}}\right) + \sum_{k=1}^{N_{III}} 4P_{IIIk}(l_{III}-\alpha_{IIIk})\left\{1-\left(\frac{l_{III}-\alpha_{IIIk}}{l_{III}}\right)^2\right\}\right)$$

l_I, l_{II}, l_{III} = span of beam between support points(m)
P_{Ii}, P_{IIj}, P_{IIIk} = maximum design wheel load between support points (*kN*)
α_{Ii}, α_{IIj}, α_{IIIk} = distance from each support point to the point of action of wheel load (See **Fig 7.7.3**)
N_I, N_{II}, N_{III} = number of wheel loads between each span

3. Scantlings of vehicle deck beams *(2017)*

Scantlings of beams of car decks may be determined by direct strength calculations using the following standards.

(1) The model of structures and the method of calculation are to be those approved by the Society.

(2) Loads are to be assumed as follows;

(a) 1.5×maximum design wheel load for loaded condition with vehicles on car decks.

(b) 1.2×maximum design wheel load for vehicles used for cargo handling only(forklifts or similar vehicles used for handling cargo in ports only).

(3) The allowable stressed for calculation of section moduli are to be as shown in **Table 7.7.4.**

(4) Considering corrosion, etc, the section moduli obtained on the basis of conditions (1) to (3) above are to be multiplied by 1.2 to determine the actual section moduli.

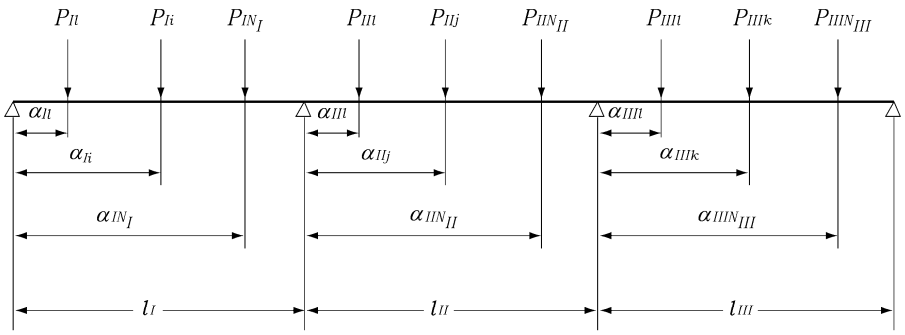


Fig 7.7.3 Measurement of P_{Ii}, α_{Ii}, l_I

Table 7.7.4 Permissible stress $(\mathrm{N/mm^2})$

Members	Vehicles used for cargo handling only	Other vehicle
Longitudinal beams of strength decks in midship region	$\frac{235}{K}-80f_D$	$\frac{235}{K}-150f_D$
Elsewhere	$\frac{235}{K}$	$\frac{235}{K}$

4. Movable vehicle deck girder

(1) General

Deck girders of movable vehicle decks and similar constructions are to be in accordance with the requirements in this Section in addition to **Pt 3, Ch 11, 103.**

(2) Strength requirement

The scantlings of movable vehicle deck girders are to be determined with the following requirements in (A) through (C).

(A) The effective width of compressive plate flange for each girder is to be determined by the following (a) and (b) corresponding to the stiffening direction of panel.

(a) Effective width for girders parallel to the stiffening direction

The value specified in Rule **Pt 3, Ch 1, 604.**

(b) Effective width for girders crossing at right angles with the stiffening direction

$$b_{eft} = \sum_n (\frac{C_{et} \cdot a}{2}) \quad (\mathrm{mm})$$

In case buckling stiffeners for deck plate are fitted properly, these may be taken into account for the determination of effective width. However, it is not to exceed the value specified in Rule **Pt 3, Ch 1, 604.**

C_{et} : Coefficient as given by the following formula. Where, however, C_{et} exceeds 1.0, C_{et} is to be taken as 1.0.

$$C_{et} = (\frac{3}{\beta} - \frac{1.75}{\beta^2})\frac{b}{a} + (\frac{0.075}{\beta} + \frac{0.75}{\beta^2})(1 - \frac{b}{a})$$

n : 1 for girders located on the periphery of vehicle deck, and 2 for the others
a : Spacing of girders crossing at right angles with the stiffening direction (mm)
b : Spacing of stiffeners (mm)
β : Coefficient as given by the following formula

$$\beta = \frac{b}{t}\sqrt{\frac{\sigma_F}{E}}$$

t : Thickness of vehicle deck plating (mm)
σ_F : Minimum upper yield stress or proof stress of the vehicle deck material (N/mm^2)
E : Modulus of elasticity of the material to be assumed equal to 2.06 $\times 10^5$ (N/mm^2) for steel.

(B) Design load and allowable stresses are to be in accordance with the requirements of following (a), (b).
(a) Design load P (kN/mm^2)
- For loaded condition with vehicles on vehicle decks

$$P = 1.5(p + w_{deck})$$

p : Design load on vehicle deck (kN/mm^2)
w_{deck} : Tare of vehicle deck per unit area (kN/mm^2)

- For vehicles used for cargo handling only (fork lifts or similar vehicles used for handling cargo in ports only)

$$P = 1.2(p + w_{deck})$$

(b) Allowable stresses (N/mm^2)
As specified in **Table 7.7.5**. Where, $\sigma_F(N/mm^2)$ is minimum upper yield stress or proof stress of the material.

Table 7.7.5 Allowable stress

Normal stress	$0.8\sigma_F$
Shear stress	$0.46\sigma_F$

(C) In case the scantlings of girders are determined based upon direct calculations, the method of assessments is to be a grillage model analysis or that can take account of the elastic buckling effects of compression panels of vehicle deck. Otherwise, it may be acceptable that elastic FEM analysis by using shell elements model is carried out and, in addition, buckling strength of compression panels is checked complying with the requirements of **Pt 3, Annex 3-2, III.2.**

(3) Structural details
(A) Fillet weld of the connection of girder webs to the vehicle deck is to be in accordance with **Table 7.7.6.**

(B) The thickness of web plates is not to be less than that obtained by the following formula, except where buckling strength of web plate is examined precisely.

$$\frac{d}{C} + 1.0$$

d : Depth of girders (mm)
C : Coefficients are given by the followings.
65 for symmetrically flanged girders
55 for asymmetrically flanged girders

Table 7.7.6 Fillet weld of girder to movable vehicle deck

	Panel on which vehicular traffic is frequent (1)	Panels other than the specified in the left column
1) Girders on the deck panel periphery	F2 (Both sides)	F2 (Both sides)
2) Within $0.3l$ midspan of girders other than mentioned in (2)		
3) Within $0.1l$ end part of girders other than mentioned (2)		
4) Intersection for $0.2l'$ of girders other than mentioned in (3)		
5) Other than those mentioned above		F2 (One side, at least)

(1) Deck panels which are subject to the dynamic load in the vicinity of ramp way and are on the route between a ramp way and another ramp way to reach another deck

(2) l : The total length of each girder

(3) l' : The span of each girder, and $0.1l'$ on either side of the inter section of girders is to be welded

(4) $F2$: As specified in Rule **Pt 3, Ch 1, Table 3.1.11**

5. Supporting structures of movable vehicle deck

(1) The requirements in this section apply to structures supporting movable vehicle decks.
(2) Considering the shape, designed load, etc., of deck panels, supporting structures of movable vehicle decks are to be arranged appropriately.
(3) The connection of supporting members to hull structural members is to be suitably constructed so as to avoid stress concentration. If necessary, suitable reinforcement is to be provided by means of stiffeners, brackets, etc.
(4) In case deck panels are suspended by wire ropes, the ropes are to comply with the requirements of **Pt 4** of the Rules or the requirements of the standards as deemed appropriate by the Society, and subjected to suitable corrosion prevention treatment.
The safety factor of the wire ropes is not to be less than the following value, but may not exceed 4.

$$\frac{10^4}{8.85W + 1910}$$

Where,

W : Safe working load (ton)

(5) Scantlings of supporting structural members are to be determined to withstand the design loads defined in **4** (B) (a) using the following allowable stresses.

shear stress : $\tau = 0.34\sigma_F$

bending stress : $\sigma = 0.50\sigma_F$

equivalent stress : $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 0.64\sigma_F$

Where,

σ_F : Minimum upper yield stress or proof stress of the material ($\mathrm{N/mm^2}$)

303. Deck loads 【See Guidance】*(2020)*

1. Deck load h (kN/m^2) for the weather deck is not to be less than that obtained from the following formula.

$h = a(bf - y)$ (kN/m2)

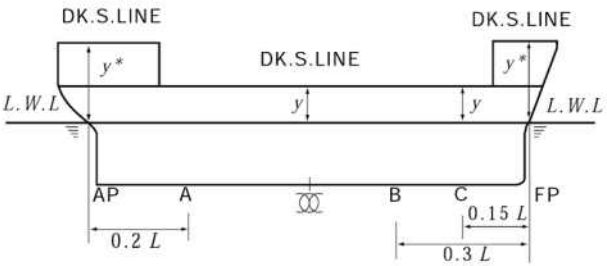
where:

a, b = as given by **Table 7.7.7** according to the position of decks.

C_{b1} = block coefficient, however, where C_b is less than 0.6, C_{b1} is to be taken as 0.6, and where C_b is 0.8 and over, C_{b1} is to be taken as 0.8.

f = as given in **Table 7.7.8.** (see **Fig 7.7.4**):

y = vertical distance from the load line to weather deck at side (m), and y is to be measured at fore end for deck forward of 0.15L abaft the fore end; at 0.15L abaft the fore end for deck between 0.3L and 0.15L abaft the fore end; at midship for deck between 0.3L abaft the fore end and 0.2L afore the aft end; and at aft end for deck aftward of 0.2L afore the aft end (see **Fig 7.7.4**)



Abaft A y is to be measured at AP.
Between A and B y is to be measured at ⊗.
Between B and C y is to be measured at C.
Afore C y is to be measured at FP.
y^* : In case of no superstructure, y is the distance to the upper deck.

Fig 7.7.4 Position of measuring y

Table 7.7.7 Values of a and b

Line	Position of deck	a			b
		Beams(1), Deck plating	Pillars	Deck girders	
I	Forward of $0.15L$ abaft the fore end	14.7	4.90	7.35	$1+\frac{0.338}{(C_{b1}+0.2)^2}$
II	Forward of $0.15L$ and $0.3L$ abaft the fore end	11.8	3.90	5.90	$1+\frac{0.158}{(C_{b1}+0.2)^2}$
III	Between $0.3L$ abaft the fore end and $0.2L$ afore the aft end	6.90	2.25	2.25(2) 3.45(3)	1.0
IV	Afterward of $0.2L$ afore the aft end	9.80	3.25	4.90	$1+\frac{0.123}{(C_{b1}+0.2)^2}$

NOTE:
(1) Where L is 150 m or less, value a may be multiplied by the value of following formula:
$C=0.0055L+0.175$
(2) In case of longitudinal deck girders outside the line of hatchway opening of the strength deck for midship part.
(3) In case of deck girders other than (2).

2. h for deck in Line II in **Table 7.7.7,** need not exceed that in Line I.

3. h is not to be less than that obtained from the formulae in **Table 7.7.3,** irrespective of the provisions in **1.** and **2.**

4. Where multi-tier decks of more than 3 are fitted, however, the load applied to the weather deck is to be greater than the value obtained by multiplying the load obtained in **1., 2.** and **3.** by the values in **Table 7.7.4**.

5. In the provision of "h" specified in **303.,** a weather deck may be regarded as follows in accordance with the vertical distance, H_D from an imaginary freeboard deck to the weatherdeck at side.

$h_s \leq H_D < 2h_s$: Superstructure deck of first tier above an imaginary freeboard deck

$2h_s \leq H_D < 3h_s$: Superstructure deck of second tier above an imaginary freeboard deck

$nh_s \leq H_D < (n+1)h_s$: Superstructure deck of nth tier above an imaginary freeboard deck

Table 7.7.8 Coefficient f

Length of ship	f
$L < 150$ m	$\frac{L}{10}e^{-\frac{L}{300}}+\left(\frac{L}{150}\right)^2-1.0$
150 m $\leq L <$300 m	$\frac{L}{10}e^{-\frac{L}{300}}$
300 m $\leq L$	11.03

Table 7.7.9 Minimum Values of h

Line	Position of deck	$h^{(1)}$	C	
			Beams(2), Deck plating	Pillars, Deck girders
I and II	Forward of $0.3L$ abaft the fore end	$C\sqrt{L'+50}$	4.20	1.37
III	Between $0.3L$ abaft the fore end and $0.2L$ afore the aft end		2.05	1.18
IV	Afterward of $0.2L$ afore the aft end	$C\sqrt{L'}$	2.95	1.47
Second tier superstructure deck above the freeboard deck 1.95 0.69			1.95	0.69

NOTES:
(1) L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
(2) Where L is 150 m or less, value C may be multiplied by the value of following formula:.

$$0.0055L+0.175$$

Table 7.7.10 Coefficient for pressure on exposed decks

Position of exposed deck	
Freeboard deck	1.0
3rd tier deck	0.32
4th tier deck	0.25
5th tier deck	0.20
6th tier deck	0.15
7th tier deck and above	0.10

CHAPTER 10 DOUBLE HULL TANKER

Section 1 General

101. Application 【See Rule】

1. Application

(1) For ships having the structural features similar to double hull tankers, the requirements in this Chapter of the Rules are to be applied.

(2) Unless otherwise specially noted, the prescriptions in other Parts apply for matters common to both cargo ships and tankers.

2. Proposal of novel construction type

In the event that a novel construction type is proposed, scantlings are to be determined by carrying out comparative calculations with the standard structural model conforming to the requirements of the Rules. Submission of data covering the results of model experiments or real ship experiments may be requested by the Society as necessary.

3. Ships carrying liquid cargoes other than petroleum

(1) The scantlings of structural members of the cargo oil tank part of tankers carrying liquid cargoes of a specific gravity ρ exceeding 1.0 are to be of the values obtained by the following two procedures, whichever is greater:

(a) To calculate for all of the structural members in accordance with the relevant requirements of the Rules

(b) To calculate for respective structural members in accordance with the following prescription:

(i) The scantlings of the bulkhead plates, stiffeners attached bulkhead plating and girders attached bulkhead plating are to be calculated h in the formulae specified in **Sec 2** to **4** of the Rules by multiplying gravity ρ.

(ii) The scantlings of girders and floors in double bottom and girders and transverses in double side hull are to be calculated h' in the formulae specified in **403.** and **404.** of the Rules by multiplying gravity ρ.

(iii) The values of ρ are to be selected for respective cases except those contained in **Table 7.10.1.**

(2) For tankers carrying dangerous chemicals in bulk, the requirements in **Ch 6** of the Rules are also to be applied.

Table 7.10.1 Value of ρ

Cargo	ρ
Molasses	1.4
Asphalt	1.1
Concentrated sulphuric acid	1.85

4. Minimum distance between asphalt cargo tank and the adjacent members

For asphalt carrier which all cargo tanks are independent tank, the requirements of **Ch 1 Sec 1 101. 4** are applicable to these ships.

102. Location and separation of spaces 【See Rule】

1. The size and arrangement of cargo oil tanks segregated ballast tanks are to comply with the requirements of **MARPOL 1973/78 Annex 1 Reg. 19.**

2. Cofferdams and bulkheads bounding cargo oil tanks

(1) In case where a cargo oil tank is adjacent to the fore peak (fore peak tank), the collision bulkhead is to be free from openings.

(2) Divisions between compartments defined as cofferdams and other compartments (except cargo oil tanks and fuel oil tanks) are not to have any openings with the exception of bolted watertight manholes provided in chain locker bulkheads, etc. (no watertight door is permitted).

3. Airtight bulkheads

(1) Cofferdams which are not utilized as main or auxiliary pump rooms and compartments utilized as cofferdams under the freeboard deck are to meet the requirements for the strength of deep tanks. The bulkhead between the main pump room and engine room is to have structural scantlings of watertight bulkheads in ships of not less than 100 m in length and of airtight bulkheads in ships of less than 100 m in length.

(2) The scantlings of airtight bulkheads for which no hydrostatic tests are required are to comply with the following standards. Airtightness tests may be replaced by hose tests.

(A) The plate thickness is not to be less than 6 mm, which may, however, be reduced to 4.5 mm in ships of less than 100 m in length.

(B) The section modulus of stiffeners and girders is to be 50 % of the Rule requirements for watertight bulkheads. Where connected to shell and decks, however, these stiffening members are to be of such an effectiveness as is equivalent to frames and beams.

4. Superstructures and deckhouses

The deckhouse protecting the entrance to pump rooms is to be in accordance with the following requirements:

(1) The strength of front wall is to be equivalent to that of wall of the bridge.

(2) The strength of side walls and after wall are to be equivalent to that of front wall of the poop.

5. Pipe duct in double bottom

"Adequate mechanical ventilation" defined in **102. 8** (3) of the Rules is to be in accordance with the requirements in **Ch 6, 1203.** of the Rules.

6. When applying the requirements in **102. 3** (4) of the Rules, **Ch 6, 304. 4 Table 7.6.1 of the Guidance** may be applied to the minimum dimension of clear opening, where deemed appropriate by the Society. Where differently deliberated by the competent Flag Administrations, shall be in accordance with the relevant requirements.

103. Minimum thickness【See Rule】

With respect to the requirements of **103. 1** of the Rules, this requirements are applicable to cargo oil tank and deep tank with larger length or width than $0.1L + 5.0(\mathrm{m})$.

Section 2 Bulkhead Plating

201. Bulkhead plating in cargo oil tanks and deep tanks 【See Rule】

1. "Bulkhead plating" referred to in this Chapter of the Rules means those plate members used in the boundaries of cargo oil tanks and deep tanks where longitudinal bulkheads, transverse bulkheads, decks plates, side shell and inner bottom plates are included.

2. Distribution of Δh and measurement of b_t for L-Type and U-Type tank of **Table 7.10.2** of the Rules are to be in accordance with **Fig 7.10.1.**

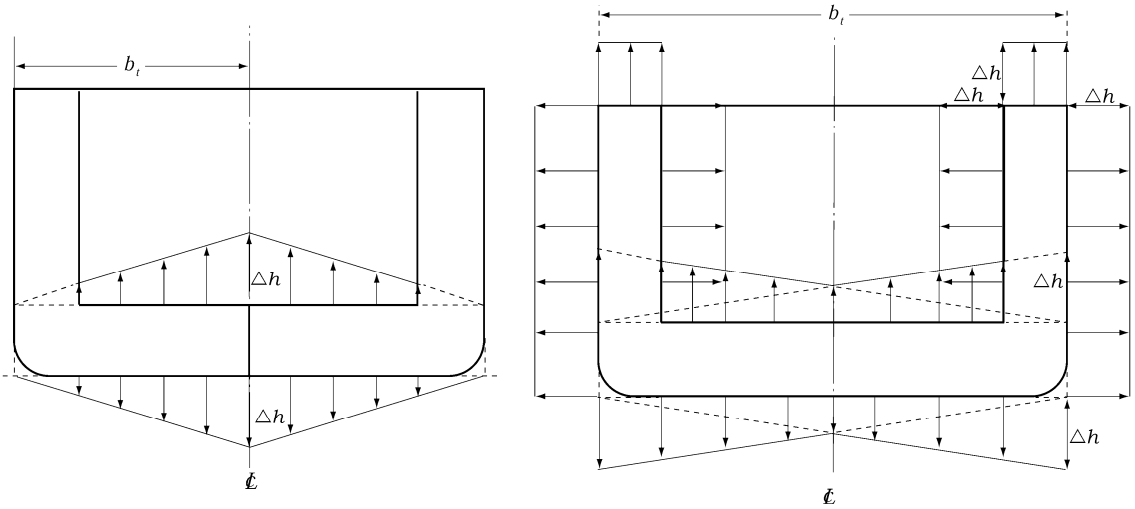


Fig 7.10.1 b_t **and** $\triangle h$ **of L-type and U-type tanks**

3. In the provision of h_3 specified in **Table 7.10.2** of the Rules, for side shell plating, a water head corresponding to the minimum draught amidship $d_{\min}$ (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be $d_{\min}$, value at point $d_{\min}$ above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation.

202. Swash Bulkheads 【See Rule】

1. Arrangements of swash bulkheads

In case where the length or breadth of a cargo oil tank exceeds, 15 m or 0.1L(m), whichever is greater, swash bulkheads are to be provided in cargo oil tanks. Where, however, this requirement may be dispensed with if special consideration is given to sloshing.

(1) The breadth and thickness of the uppermost and lowest strakes of the centreline swash bulkhead may be 90 % of those required by the Rules for the uppermost and lowest strakes, respectively, of the longitudinal oiltight bulkhead.

(2) The "opening ratio" means the ratio of the sum of areas of openings, except slots and scallops, to the area of the bulkhead.

(3) The section modulus of stiffeners is to be obtained from the following formula.

$$Z = CSh_2l^2 \quad (\mathrm{cm}^3)$$

where:

C = coefficients given below;

both ends effectively bracketed : C = 7.1

one end effectively bracketed and the other end supported by girder : C = 8.4

both ends supported by girders : C = 10.0

h_s = value obtained from the following formula. In no case is it to be less than 2.0.

$$h_s = (0.176 - 0.00025L)(1-\alpha)l_T$$

α = opening ratio of bulkhead plating.

l_T = length of tank (m).

S and l = spacing of stiffeners and span of stiffener between supports (m).

(4) In applying the requirements of **405. 1** to **3** of the Rules, the scantlings of girders supporting stiffeners are to be obtained in such a way that values of h specified in the requirements under consideration referred to are not less than that obtained by substituting h with h_s specified in (3).

Section 3 Longitudinals and Stiffeners

301. Longitudinals 【See Rule】

For the assessment fatigue strength of ship structure according to **301. 4** of the Rules is to comply with **Pt 3, Annex 3-3** of the Guidance.

Section 4 Girders

401. General 【See Rule】

1. In application of **401. 2** of the **Rules**, "when approved by the Society" means any of the following (1) to (3) among ships of 200 m or less.

(1) Tankers with double bottom structures having longitudinal bulkhead only on the centreline, (hereinafter referred to as "Type A tankers") (See Fig **3.3.7** of the Rules)

(2) Tankers with double hull structures having no longitudinal bulkhead on the centreline (hereinafter referred to as "Type C tankers") (See Fig **3.3.7** of the Rules)

(3) Tankers with double hull structures having longitudinal bulkhead only on the centreline (hereinafter referred to as "Type D tankers") (See Fig **3.3.7** of the Rules)

2. In tankers without partial loading conditions such as half-loading or alternate loading, if the spacing of girders and floors in double bottom and stringers and transverses in double side hull according to type A, C, D tankers of **Par 1** are smaller than the values shown in (1) and (2) , the spacing may be increased to the values given in (1) and (2) :

(1) Girders in double bottom and stringers in double side hull ..... 4.1 (m)

(2) Floors in double bottom and transverses in double side hull ..... 2.8 (m)

402. Direct strength calculations for girders 【See Rule】

When determining the scantlings of girders for double hull tankers by direct strength calculations, the procedure is to comply with the **Pt 3, Annex 3-2** of the Guidance.

403. Scantlings of girders and floors in double bottom 【See Rule】

1. The thickness of centre girders and side girders in double bottom is not to be less than the greatest of either of the value t_1 specified in the following (1) , t_2 or t_3 specified in the following (2). Where, however, the thickness of centre girders of tankers having the longitudinal bulkhead on the centreline may be determined using only t_3.

(1) The thickness obtained from the following formula according to the each location in the cargo oil tank

$$t_1 = C_1 K \frac{S h_B x}{d_0 - d_1} + 1.5 \quad (\mathrm{mm})$$

where :

S = distance between the centres of two adjacent spaces from side girder under consideration to the adjacent girders or the inner end of tank side brackets (m).

h_B = the values obtained from the following formulae, whichever is the greater :

$$h_{B1} = 0.6d + 0.026L \quad (\mathrm{m})$$

$$h_{B2} = h' - (d - 0.026L) \quad (\mathrm{m})$$

h' = vertical distance from the top of the inner bottom plating to the top of hatches (m).

d_0 = depth of side girder under consideration (m).

d_1 = depth of opening at the point under consideration (m). Where, however, if vertical webs attached the transverse bulkhead are provided in the cargo oil tank, openings in girders provided within the range between the transverse bulkhead and the inner end of bracket of the lower vertical webs under consideration may be omitted except when the Society considers it to be necessary. (See **Fig 7.10.2**)

x = longitudinal distance between the centre of l_T of each cargo oil tank and the point under consideration (m). Where vertical webs attached the transverse bulkhead are provided in the cargo oil tank, x may be calculated as the distance up to the inner end of the bracket attached the lower vertical webs. And where x is under $0.25l_T$, x is to be taken as $0.25l_T$.(see Fig **7.10.2**)

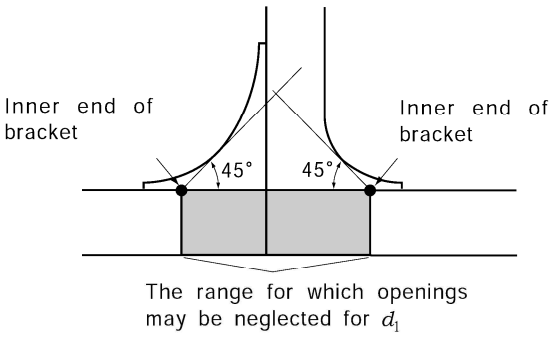


Fig 7.10.2 Based point of d_1, x, y and z

C_1 = coefficient obtained from **Table 7.10.2** and **Table 7.10.3** depending on b/l_T. For intermediate values of C_1 is to be obtained by linear interpolation.

b = distance between the side shell plating and the longitudinal bulkhead on the centreline of the hull at the top of the inner bottom plating at the midship part (m).

l_T = length of the cargo oil tank under consideration (m).

Table 7.10.2 Coefficient of type A and D tanker

b/l_T		0.5 and under	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3 and under
C_1	Type A	0.045	0.054	0.061	0.068	0.073	0.076	0.079	0.081	0.082
	Type D	0.037	0.044	0.051	0.059	0.065	0.070	0.074	0.076	0.079

Table 7.10.3 Coefficient C_1 of type C tanker

b/l_T	1.0 and under	1.2	1.4	1.6 and over
C_1	0.073	0.079	0.082	0.083

(2) The thickness obtained from the following formula according to the each location in cargo oil tank :

$$t_2 = 8.6\sqrt[3]{\frac{H^2 a^2}{C_3 K}(t_1 - 1.5)} + 1.5 \quad (\text{mm}), \qquad t_3 = \frac{C_4 a}{\sqrt{K}} + 1.5 \quad (\text{mm})$$

where :

a = depth of girders at the point under consideration (m)
Where, however, if horizontal stiffeners are provided at the half way of the depth of girders, a is the distance from the horizontal stiffener under consideration to the bottom shell plating or inner bottom plating, or the distance form the horizontal stiffener under consideration to the bottom shell plating or inner bottom plating, or the distance between the horizontal stiffeners under consideration (m)

t_1 = thickness of girders calculated under the requirements of (1) according to the type of tankers (mm)

C_3 = coefficient obtained from **Table 7.10.4** according to the ratio of spacing S_1 (m) of stiffeners provided in the direction of the depth of girders and a. For intermediate values of S_1/a, C_3 is to be determined by linear interpolation.

S_1 = spacing of stiffeners provided depthwise on the girder (m)

H = value obtained from the following formulae:

(a) Where the girder is provided with an unreinforced opening.

$$H = 1+0.5\phi/a$$

where :
ϕ = major diameter of the openings (m)
α = the greater of a or S_1 (m)

(b) In cases other than(a) : H = 1.0

C_4 = coefficient obtained from **Table 7.10.4** depending on S_1/a. For intermediate values of S_1/a, C_4 is to be obtained by linear interpolation.

Table 7.10.4 Coefficient C_3 and C_4

S_1/a		0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6 and over
C_3		64	38	25	19	15	12	10	9	8	7	7
C_4	center girder	4.4	5.4	6.3	7.1	7.7	8.2	8.6	8.9	9.3	9.6	9.7
	side girder	3.6	4.4	5.1	5.8	6.3	6.7	7.0	7.3	7.6	7.9	8.0

2. The thickness of floors in double bottom is not to be less than the greatest of either of the value t_1 specified in the following (1), t_2 or t_3 specified in the following (2).
(1) The thickness t_1 obtained from **Table 7.10.5** according to the type of oil tank

Table 7.10.5 Thickness of floor t_1

Type of tankers	Type A tankers	Type C and D tankers
t_1	$t_1 = C_2 K \frac{Sbh_B}{d_0 - d_1}\left(1 - \frac{4y}{3b'}\right) + 1.5 \quad (\mathrm{mm})$	$t_1 = C_2 K \frac{Sbh_B}{d_0 - d_1} \times \frac{2y}{b'} + 1.5 \quad (\mathrm{mm})$

S = spacing of floors (m)

h_B = the values obtained from the following formula, whichever is the greater. Where, however, for tankers without abnormal loading conditions such as half-loading or alternate loading, specified in **Par 1 (1)** may be used

$$h_{B1} = d + 0.026L \quad (\mathrm{m})$$
$$h_{B2} = h' - (0.6d - 0.026L) \quad (\mathrm{m})$$

d_0 = height of floors at the point under consideration (m).

d_1 = depth of opening at the point under consideration (m). Where, however, if transverses attached the longitudinal bulkhead or side transverses attached the side shell plating are provided in the cargo oil tank, openings in floors provided within the range between the longitudinal bulkhead or side shell plating and the inner end of the brackets of the lower transverses under consideration may be omitted except when the Society considers it to be necessary. (See **Fig 7.10.2**)

b' = b (m) of **Par 1 (1)** measuring at the floors under consideration.

y is to comply with type of tankers

(A) Type A of tankers : Athwartship distance at the floors under consideration from centreline of the hull to the point under consideration (m). However, if transverses attached the longitudinal bulkhead are provided in the cargo oil tank, for space between the longitudinal bulkhead and the inner end of the bracket of lower transverses under consideration, y may be calculated as the distance up to the inner end of the bracket under consideration. If y exceeds $0.3b'$, y is to be taken as $0.3b'$.

(B) Type C of tankers : Athwartship distance at the floors under consideration from the centreline of the hull to the point under consideration (m). However, if brackets attached the lower transverses of double side hull are provided, y may be calculated as the distance up to the inner end of the bracket under consideration. If y is under $0.25b'$, y is to be taken as $0.25b'$.

(C) Type D of tankers : Athwartship distance at the floors under consideration from centre of b' to the point under consideration (m). However, if brackets attached the lower transverses of double side hull or the lower transverses of the longitudinal bulkhead on the centreline of the hull in the cargo oil tank are provided, y may be calculated respectively as the distance up to the inner end of the bracket attached the lower transverses of double side hull or up to the inner end of the bracket attached the lower transverses of longitudinal bulkhead on the centreline of the hull. If y is under $0.25b'$, y is to be taken as $0.25b'$.

C_2 = coefficient obtained from **Table 7.10.6** and **Table 7.10.8** depending on b/l_T. For intermediate values of C_2 is to be obtained by linear interpolation.

b, l_T and h' are to be in accordance with the requirements of **Par 1 (1).**

(2) The thickness t_2 or t_3 obtained from the following formula

$$t_2 = 8.6\sqrt[3]{\frac{H^2a^2}{C_3K}(t_1-1.5)}+1.5 \quad (\mathrm{mm}), \qquad t_3 = \frac{8.5S_2}{\sqrt{K}}+1.5 \quad (\mathrm{mm})$$

where :

a = depth of floors at the point under consideration(m)
Where, however, if horizontal stiffeners are provided at the half way of the depth of floors, a is the distance from the horizontal stiffener under consideration to the bottom shell plating or inner bottom plating, or the distance form the horizontal stiffener under consideration to the bottom shell plating or inner bottom plating, or the distance between the horizontal stiffeners under consideration(m)

t_1 = thickness of floors calculated under the requirements of (1) according to the type of tankers(mm)

C_3 = coefficient obtained from **Table 7.10.9** according to the ratio of spacing S_1 (m) of stiffeners provided in the direction of the depth of floors and a. For intermediate values of S_1/a, C_3 is to be determined by linear interpolation.

S_1 = spacing of stiffeners provided depthwise on the floor(m)

H = value obtained from the following formulae **Par 1.** (1)

S_2 = S_1 or a, whichever is the smaller(m)

3. When calculating the thickness of side girder just under the hopper plate of bilge hopper tank, S in the formulae in **Par 1.** (1) and **Fig 7.10.3.** is to be measured, as a standard, as shown in **Fig 7.10.3.** For the hopper plate within the range of l in the figure, the sectional area obtained form the following formula may be included into the effective sectional area of the same side girder under consideration. However, if l exceeds the breadth of the hopper plate b_H, l is to be taken as b_H.

$$A_e = 10\Sigma h_i t_i\left(1-\frac{\theta}{90}\right) \quad (\mathrm{cm}^2)$$

h_i = breadth of hopper plate within l (mm)

t_i = thickness of hopper plate − 2.5 (mm)

θ = angle between side longitudinal girder plate and hopper plate(*degree*)

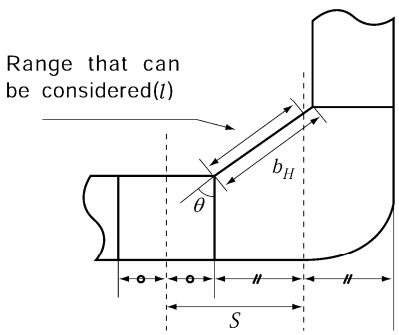


Fig 7.10.3 Measured method of S

Table 7.10.6 Coefficient C_2 of the Type A tankers

b/l_T	0.5 and under	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3 and over
C_2	0.047	0.048	0.047	0.046	0.045	0.043	0.041	0.039	0.037

Table 7.10.7 Coefficient C_2 of the Type C tankers

b/l_T	1.0 and under	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6 and over
C_2	0.036	0.033	0.031	0.028	0.026	0.024	0.022	0.021	0.019

Table 7.10.8 Coefficient C_2 of the Type D tankers

b/l_T	0.6 and under	0.7	0.8	0.9	1.0	1.1	1.2	1.3 and over
C_2	0.042	0.041	0.041	0.040	0.039	0.038	0.036	0.035

Table 7.10.9 Coefficient C_3

S_1/a	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_3	64	38	25	19	15	12	10	9	8	7

404. Scantlings of stringers and transverses in double side hull 【See Rule】

1. The thickness of stringers in double side hull is not to be less than the greatest of either of the value t_1 specified in the following (1), t_2 or t_3 specified in the following (2) :

(1) The thickness obtained by the following (1) or (2) according to the type of tankers :

$$t_1 = C_5 K \frac{S h_s x}{d_0 - d_1} + 1.5 \quad (\mathrm{mm})$$

where :

S = breadth of part supported by stringers (m).

h_s = the values obtained from the following formulae, whichever is the greater :

$$h_{s1} = (0.6d - d_3) + 0.038L \quad (\mathrm{m})$$
$$h_{s2} = h' \quad (\mathrm{m})$$

h' = vertical distance from the upper end of bilge hopper, if provided, or top of inner bottom plating to top of hatches (m).

d_3 = height of double bottom at ship's sides (m). Where, however, vertical distance up to the upper end of bilge hopper, if provided.

d_0 = depth of stringers (m).

d_1 = depth of opening at the point under consideration (m). Where, however, if horizontal girders attached the transverse bulkhead are provided in the cargo oil tank, openings in stringers provided within the range between the transverse bulkhead and the inner end of bracket at the end of horizontal girders under consideration may be omitted except when the Society considers it to be necessary. (See **Fig 7.10.2**)

x = longitudinal distance between the centre of l_T of each cargo oil tank and the point under consideration (m). However, if horizontal girders attached the transverse bulkhead are provided in the cargo oil tank, x may be calculated as the distance up to the inner end of bracket attached the end of horizontal girders under consideration. If x is under $0.25l_T$, x is to be taken as $0.25l_T$. (See **Fig 7.10.2**)

C_5 = coefficient obtained from **Table 7.10.10** depending on D'/l_T. For intermediate values of D'/l_T, it is to be obtained by linear interpolation.

D' = value obtained from the following formula :

$D' = D - d_3$ (m)

l_T = length of the cargo oil tank under consideration (m).

Table 7.10.10 Coefficient C_5

D'/l_T		0.5 and under	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3 and over
C_5	Type C	0.013	0.019	0.025	0.030	0.034	0.037	0.039	0.042	0.045
	Type D	0.020	0.024	0.028	0.032	0.035	0.038	0.040	0.042	0.045

(2) The thickness t_2 or t_3 obtained from the following formulae according to the location in the cargo oil tank.

$$t_2 = 8.6\sqrt[3]{\frac{H^2a^2}{C_6K}(t_1 - 1.5)} + 1.5 \quad (\text{mm}), \qquad t_3 = \frac{8.5S_2}{\sqrt{K}} + 1.5 \quad (\text{mm})$$

where :

a = depth of stringers at the point under consideration (m). Where, however, if horizontal stiffeners are provided at the half way of the depth of stringers in the direction of the length of stringers, a is the distance from the horizontal stiffener under consideration to the side shell plating or the longitudinal bulkhead of double side hull or the distance between the horizontal stiffeners under consideration (m).

t_1 = thickness of stringers calculated under the requirements of (1) (mm).

C_6 = coefficient obtained from **Table 7.10.11** according to the ratio of spacing S_1 of stiffeners provided in the direction of the depth of stringers and a. For intermediate values of S_1/a, C_6' is to be obtained by linear interpolation.

S_1 = spacing of stiffeners provided depthwise on the stringer(m)

H = as specified in **403. 1.** (2)

S_2 = S_1 or a, whichever is the smaller

Table 7.10.11 Coefficient C_6

S_1/a	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_6	64	38	25	19	15	12	10	9	8	7

2. The thickness of transverses in double side hull is not to be less than the greatest of either of the value t_1 specified in the following (1), t_2 or t_3 specified in the following (2).

(1) The thickness obtained by the following (a) or (b) according to the type of tankers.

$$t_1 = C_7 K \frac{SD' h_s}{d_0 - d_1}\left(1 - 1.75\frac{z}{D'}\right) + 1.5 \quad (\mathrm{mm})$$

where :

S = breadth of part supported by transverses (m).

h_s = the value obtained from the following formulae, whichever is the greater. Where, however, for tankers without abnormal loading conditions such as half-loading or alternate loading, specified in **Par 1.** (1) may be used.

$$h_{s1} = (d - d_3) + 0.038L \quad (\mathrm{m})$$
$$h_{s2} = h' \quad (\mathrm{m})$$

d_0 = depth of transverses (m).

d_1 = depth of opening at the point under consideration (m). Where, however, if brackets attached the lower transverses of double side hull are provided, the openings in transverses provided within the range between the top of the inner bottom plating and the inner end of the bracket under consideration may be omitted except when the Society considers it to be necessary.(See **Fig 7.10.2**)

z = distance in the direction of ship's depth between the top of the inner bottom plating or the top of the bilge hopper, if provided, and the point under consideration (m). However, if brackets attached the lower transverses of double side hull are provided, for space between the top of the inner bottom plating and the inner end of the bracket under consideration, z may be calculated as the distance at the inner end of the bracket under consideration. If z exceeds $0.4D'$, z is to be taken as $0.4D'$.(See **Fig 7.10.2**)

C_7 = coefficient obtained from **Table 7.10.12** depending on D'/l_T. For intermediate values of D'/l_T, C_7 is to be obtained by linear interpolation.

D', h', l_T and d_3 are to be in accordance with the requirements of **Par 1** (1).

Table 7.10.12 Coefficient C_7 of the Type C and D tankers

D'/l_T		0.5 and under	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3 and over
C_7	Type C	0.052	0.051	0.049	0.046	0.043	0.041	0.038	0.036	0.034
	Type D	0.034	0.034	0.034	0.034	0.033	0.033	0.032	0.031	0.030

(2) The thickness t_2 or t_3 obtained from the following formulae.

$$t_2 = 8.6\sqrt[3]{\frac{H^2 a^2}{C_6 K}(t_1 - 1.5)} + 1.5 \quad (\mathrm{mm}), \qquad t_3 = \frac{8.5 S_2}{\sqrt{K}} + 1.5 \quad (\mathrm{mm})$$

where :

a = depth of transverses at the point under consideration (m). Where, vertical stiffeners are provided at the half way of the depth of transverses in the direction of the length

of transverses, distance from the vertical stiffener under consideration to the side shell plating or the longitudinal bulkhead of double side hull or the distance between the vertical stiffeners under consideration (m).

t_1 = thickness of transverse calculated under the requirements of (1) (mm).

C_6 and S_2 = as specified in **1.** (2)

H = as specified in **403. 1.** (2)

3. When calculating the thickness of stringers and transverses in double side hull, S in the formulae in **1,** (1) is to be measured, as a standard, as shown in **Fig 7.10.4.** For the hopper plate within the range of l in the **Fig 7.10.4,** the sectional area obtained from the following formula may be included into the effective sectional area of the stringer under consideration. However, if l exceeds the breadth of the hopper plate b_H, l is to be taken as b_H.

$$A_e = 10\sum h_i t_i \left(1 - \frac{\theta}{90}\right) \quad (\mathrm{cm}^2)$$

where :

h_i = breadth of hopper plate within l (mm)

t_i = thickness of hopper plate − 2.5 (mm)

θ = angle between side longitudinal girder plate and hopper plate (*degree*)

405. Girders and transverses in cargo oil tanks and deep tanks 【See Rule】

1. Measurement of span l

Measurement of span of girder l is to be as specified in **Fig 7.10.5.**

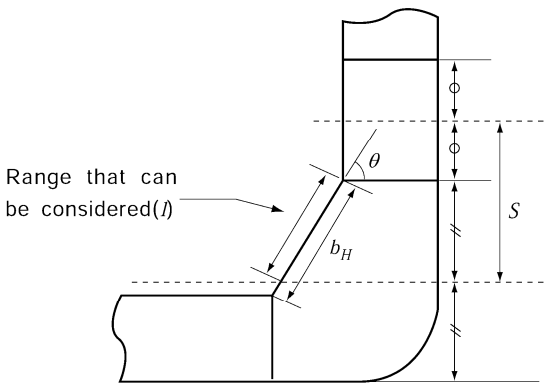


Fig 7.10.4 Measurement of S

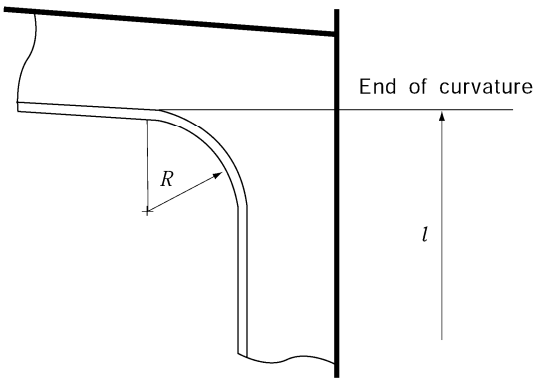


Fig 7.10.5 Measurement of l

2. Transverses on longitudinal bulkhead

(1) Even when large brackets are provided on the opposite side of a longitudinal bulkhead, span l and radius R of transverses are to be measured on the wing tank side in the same manner as in **Par 1.** But, the size of bracket b may be $0.5(b' + b'')$, except when b is to be taken as b' if b'' is smaller than b'. (See Fig **7.10.6**)

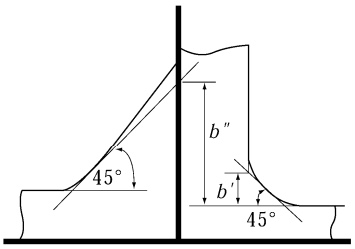


Fig 7.10.6 Measurement of b', b''

(2) In calculating the thickness of web plates in regard to shearing force, the brackets on the opposite side of longitudinal bulkheads may be taken into account.
(3) Girders on corrugated bulkheads are to be of balanced girders. Where balanced girders are not adaptable, the neutral axis is to be brought as close to the bulkhead plating as possible.

Section 5 Structural Details

501. General 【See Rule】

Areas represented by mark "○" in **Table 7.10.13** are required to penetrate longitudinal beams and longitudinals.

Table 7.10.13 Required areas of longitudinal beam and longitudinals

Length of Ship (m)	$90 \leq L < 120$	$L \geq 120$
Longitudinal beams and side longitudinals attached to sheer strake	○	○
Side longitudinals and longitudinals on longitudinal bulkhead (except those specified above)	—	○
Bottom longitudinals, inner bottom longitudinals and longitudinals on bilge strake	○	○

503. Girders and cross ties 【See Rule】

1. General

(1) The dimensions and locations of lightening holes, where provided, are to be as shown in Fig **7.10.7.**
(2) Slots are to be reinforced with collars where flanges of longitudinals are facing each other or where slots are provided at small intervals as is often the case with bilge part.
(3) In case where the depth of girders is smaller than the required depth, the section modulus of girders is to be obtained by multiplying the Rule-required section modulus by a ratio of the required depth of girder to actual depth.
(4) In pump rooms or void spaces, the thickness of webs may be reduced by 1 mm from the required thickness of webs in cargo oil tanks.
(5) The scantlings of members in segregated ballast tanks in the midship part are to be same as those of members in cargo oil tanks.
(6) In end bracket parts, at connections with cross ties, etc. of transverses where shearing stress and/or compressive stress are expected to be high, additional stiffeners are to be fitted. These parts are not to have lightening holes. If considered necessary, slots for penetration of longitudinals in these parts are to be reinforced with collars.

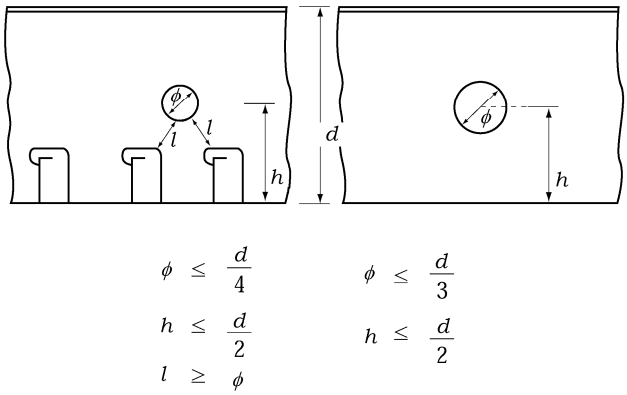


Fig 7.10.7 Locations and dimensions of lightening holes

(7) The radius of the rounded corner of girder is to be as large as practicable.
(8) Where angle bars are used instead of flat bars as stiffeners of transverses, etc., their section modulus with effective plates is to be approximately equivalent to the required ones.
(9) No scallops are to be permitted in web plates at the connection of face plates on transverses and those of girder plates. Scallops cut out for work convenience are to be filled up by welding. Abrupt change of dimensions is to be avoided carefully. (See **Fig 7.10.8**)
(10) Where longitudinal frames or stiffeners penetrate bottom transverses, side transverses and vertical webs on longitudinal bulkhead, proper reinforcement is to be made in the extents stipulated in **Table 7.10.14,** by fitting brackets on the opposite side of stiffeners on webs of transverse, for connecting longitudinals to transverse, by fitting collars at slots, or by other suitable means. In ships not exceeding 230 m in length, however, the extents of application of such reinforcement may be properly reduced.

Table 7.10.14 Reinforcing range

Member	Reinforcing range
Bottom transverse	All connections
Side transverses	All connections below the upper end of curvature of upper cross tie, or the designed maximum load line, whichever is higher. In ships of 300 m and above in length, it is recommended that similar reinforcement be applied in wider extent upward beyond the limit stipulated above.
Transverses on longitudinal bulkhead	All connections below the upper end R of longitudinal bulkhead curvature of upper cross tie.

(11) Connection of web plates is to be of butt-welding or other type of connection as deemed appropriate by the Society.

2. The intersections of inner bottom plating and bilge hopper

The construction at the intersections of the inner bottom plating and hopper plates is to be as follows:

(1) Where the constructions at the intersection of the inner bottom plating and hopper plates forms a built up construction as specified in Fig **7.10.9.** It is to comply with following:
(A) Scallops at the above-mentioned intersections in bilge hopper transverses are to be filled up by welding or closed with collar plates. (See Fig **7.10.9**)
(B) Bilge hopper transverses on the extended line of the inner bottom plating are to be fitted with gusset plates. (See Fig **7.10.9**)

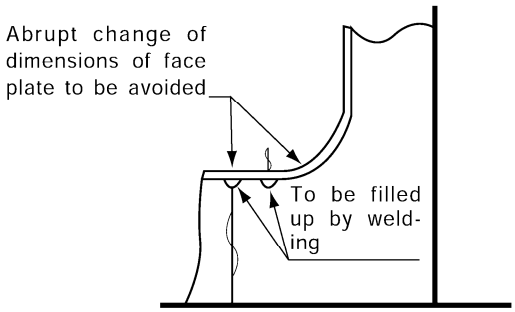


Fig. 7.10.8

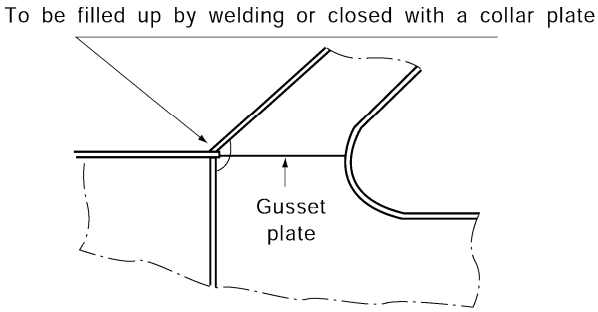


Fig. 7.10.9

(C) Where the spacing of floor plates is 2 m or more, a bracket is to be provided at the mid-length between floor plates. This bracket is to reach the inner bottom longitudinal and the hopper plate longitudinal next to the side girder located at the intersection. (See Fig **7.10.10**)

(2) Where the constructions at the intersection of the inner bottom plating and hopper plates forms a knuckle construction as specified in Fig **7.10.11.** The construction at the above mentioned intersection is to be comply with following (A) and/or (B), and (C) in addition to prescribed (1)(C) :

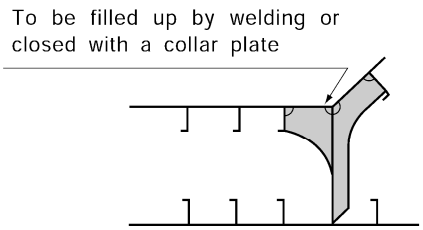


Fig. 7.10.10

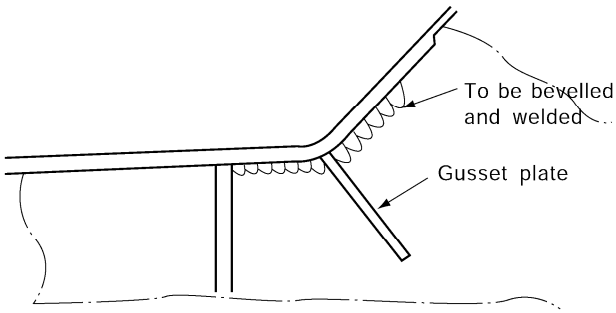


Fig. 7.10.11

(A) Knuckled part is to be bevelled and welded as far as possible.

(B) In areas where brackets are provided, gusset plates are to be attached transverses of bilge hoppers on the extended line of the inner bottom plating. In case where the radius of curvature at the knuckle is large, the number of gusset plates is to be suitably increased.

(C) Stiffeners as shown in Fig **7.10.10** are to be fitted within 300 mm afore and abaft the bracket.

3. The construction at the intersections of longitudinal bulkheads in double side hull structures and hopper plates is to comply with the requirements prescribed in **Par 2.**

4. Details of end structure of strong brackets

For detailed end structures of end brackets of girders cross tie and transverse is to be standard Fig **7.10.12.**

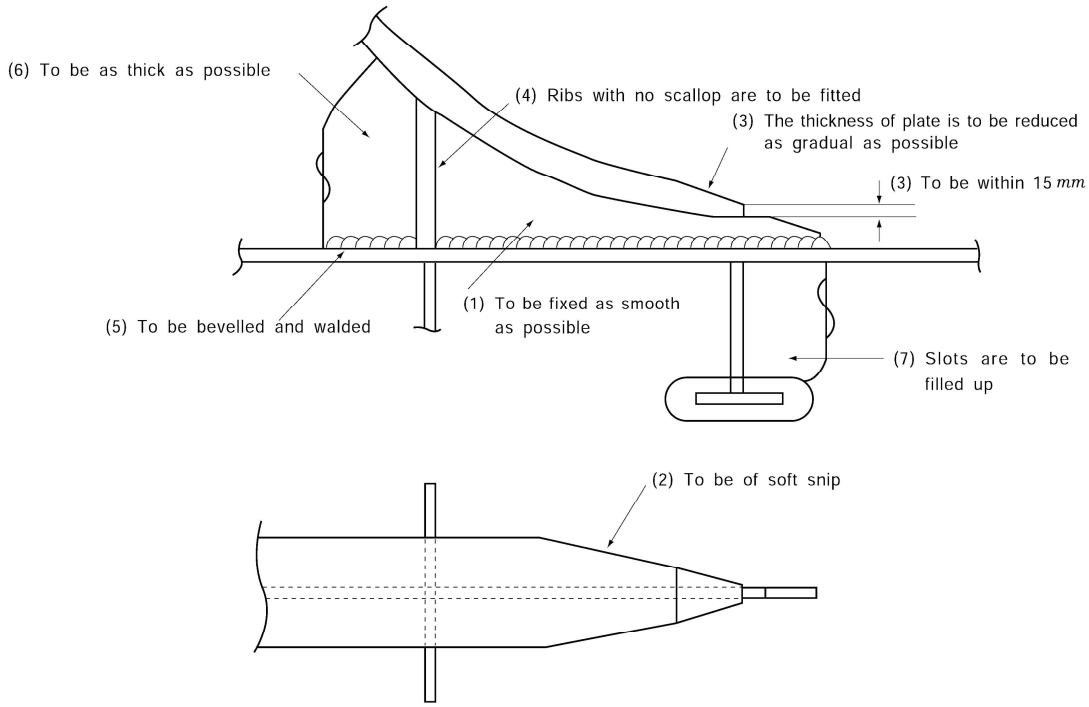


Fig. 7.10.12 Structural details of bracket toe

5. Connection of struts

In the such a construction as shown in **Fig 7.10.13,** brackets, as asterisked, are to be fitted.

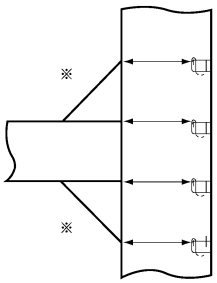


Fig 7.10.13

Section 6 Special Requirements for Corrosion

607. Thickness of inner bottom plating in cargo oil tanks 【See Rule】

1. Thickness of inner bottom plating specified in **Par 1** of the Rules is to comply with following requirement. In the ships engaged in the carriage of crude oil mainly, the thickness t of inner bottom plating is not to be less than obtained from the following formula, except where inner bottom is inclined appropriately;

$$t = 0.026L + 9.0 \quad (\mathrm{mm})$$

2. Thickness increasing range according to **Par 2** of the Rule is to comply with **Fig 7.10.14.** The thickness of range is not to be less than that specified in **607. 2** of the Rule or **Par 1** adding 2.0 mm, whichever is the greater.

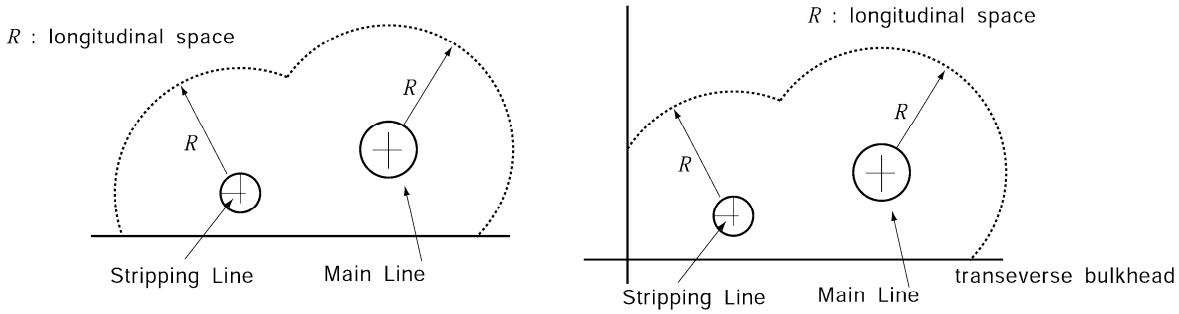


Fig. 7.10.14 Range of strengtened for corrosion of inner bottom

Section 8 Special Requirements for Tankers with Mid-deck

801. Application 【See Rule】

1. The structural members of tankers having mid-deck penetrating longitudinally through the cargo areas are to comply with the requirements in **201., 301.** and **403.** Values of h_1, h_2 and h_3 are to as specified in **Table 7.10.15.**

Table 7.10.15 Load h_1, h_2 and h_3

Provision / Load	**201.** of the Rules	**302.** of the Rules	**403.** of the Rules
h_1	Vertical distance form the lower edge of bulkhead plating to the mid-deck(m)	Vertical distance from mid-length of l for vertical stiffeners, and from midpoint between the upper and lower stiffeners for horizontal stiffeners to the mid-deck(m)	Vertical distance from mid-length of S for horizontal girders, and from mid-length of l for vertical girders to the mid-deck (m)
h_2	$0.85(h_1+\Delta h)$ (m), Δh is to be as specified in **Table 7.10.2** of the Rules.	$0.85(h_1+\Delta h)$ (m), Δh is to be as specified in **Table 7.10.2** of the Rules.	$0.85(h_1+\Delta h)$ (m), Δh is to be as specified in **Table 7.10.2** of the Rules.
h_3	0.7 times the vertical distance from the lower edge of bulkhead plating to the top of hatchway multiplied(m)	0.7 times the vertical distance from mid-length of l for vertical stiffeners, and from mid-span of the upper and lower stiffeners for horizontal stiffeners to the top of hatchway(m)	0.7 times the vertical distance from mid-length of S for horizontal girders, and from mid-length of l for vertical girders to the top of hatchway(m)

2. In case where the thickness of a mid-deck plating is counted as the top plating of the lower cargo oil tank, it is not to be less than the thickness obtained form the formula given in **Par 1** using the loads specified in **201.** of the Rules adding 1.0 mm thereto.

Section 9 Special Requirements for Hatchways and Freeing Arrangements

902. Hatchways to cargo oil tanks *(2018)* 【See Rule】

1. In case where hatchway covers of glass-fibre reinforced plastics are provided for cargo oil tanks, they are to comply with the **Ch 1, 202. 1.**

2. For the tank cleaning hatch covers, It is to comply with **Ch 1, 202. 2** and **3.**

904. Permanent gangway and passageway 【See Rule】

In application to **904. 1** of the Rules, the term "the satisfaction of the Society" means **Pt 4, Ch 4, 501.** of the Guidance.

Section 10 Welding

1002. Fillet welding 【See Rule】

In areas where bending, shearing or axial force is particularly significant, the leg length of fillet welds is to be suitably increased or to be bevelled and welded. ⚓

Annex 7-1 Additional Requirements for Oil Tankers Using Crude Oil as a Fuel for Boilers

1. Application

(1) This Annex is apply to the tankers using crude oil or slops as a fuel for main or auxiliary boilers.
(2) Requirements which are not specified in this Annex, may be applied to the related requirements of the Rules for the Classification of Steel Ships.

2. Approval drawings and documents

The approval drawings and documents are to be submitted by the following:

(A) Arrangement
(B) Arrangement of crude oil and slop tank
(C) Piping diagram
(D) Plans and documents specified in **Pt 5, Ch 1, 208.** of the Rules
(E) Power and control diagram
(F) Gas instruments and alarm arrangement
(G) Other plans and documents deemed necessary by the Society

3. The crude oil or slops used as a fuel for main or auxiliary boilers.

(1) Crude oil or slops are to be only used as a fuel on the voyage.
(2) Crude oil or slops may be taken directly from cargo tanks or flow slop tanks or from other suitable tanks. These tanks are to be fitted in the cargo tank area and are to be separated from non-gas-dangerous areas by means of cofferdams with gas-tight bulkheads.
(3) When it is necessary to preheat crude oil or slops, their temperature is to be automatically controlled and a high temperature alarm is to be fitted.

4. Boiler

(1) The whole surface of the boilers shall be gas-tight separated from the engine room. The boilers themselves are to be tested for gas-tightness before being used.
(2) Their connections (to be reduced to a minimum) are to be of the heavy flange type. Within the engine room and boiler room these pipes are to be fitted within a metal duct, which is to be gas-tight and tightly connected to the fore bulkhead separating the pump room and to the tray. This duct (and the enclosed piping) is to be fitted at a distance from the ship's side of at least 20% of the vessel's beam amidships and be at an inclination rising towards the boiler so that the oil naturally returns towards the pump room in the case of leakage or failure in delivery pressure. It is to be fitted with inspection openings with gas-tight doors in way of connections of pipes within it, with an automatic closing drain-trap placed on the pump room side, set in such a way as to discharge leakage of crude oil into the pump room. In order to detect leakages, level position indicators with relevant alarms are to be fitted on the drainage tank.
(3) Boilers shall be fitted with a suitable hood placed in such a way as to enclose as much as possible of the burners, valves and oil pipes, without preventing, on the other side, air inlet to burner register.
  (A) The hood, if necessary, is to be fitted with suitable doors placed in such a way as to enable inspection of and access to oil pipes and valves placed behind it.
  (B) It is to be fitted with a duct leading to the open in a safe position, the outlet of which is to be fitted with a suitable flame wire gauze, easily dismountable for cleaning.
  (C) At least two mechanically driven exhaust fans having spark proof impellers are to be fitted so that the pressure inside the hood is less than that in the boiler room.
    (a) The exhaust fans are to be connected with automatic change over in case of stoppage or failure of the one in operation.
    (b) The exhaust fan prime movers shall be placed outside the duct and a gas-tight bulkhead penetration shall be arranged for the shaft.
(4) When using fuel oil for delivery to and return from boilers fuel oil burning units in accordance with **Pt 5, Ch 6, 902.** of the Rules shall be fitted in the boiler room. Fuel oil delivery to, and returns from, burners shall be effected by means of a suitable mechanical interlocking device so that running on fuel oil automatically excludes running on crude oil or vice versa.
(5) One pilot burner in addition to the normal burning control is required.

(6) The boiler compartments are to be fitted with a mechanical ventilation plant and shall be designed in such a way as to avoid the formation of gas pockets. Ventilation is to be particularly efficient in way of electrical plants and machinery and other plants which may generate sparks. These plants shall be separated from those for service of other compartments and shall be in accordance with Classification Societies' requirements.
(7) Means are to be provided for the boiler to be automatically purged before firing.

5. Observation tanks

(1) When crude oil is heated by stream or hot water the outlet of the heating coils should be led to a separate observation tank.
(2) The observation tank is to be fitted with a air pipes and the opening end is to be flame screen led to the safe position.

6. Installation of associated components

(1) Pumps, strainers, separators and heaters etc. The whole system of pumps, strainers, separators and heaters, if any, shall be fitted in the cargo pump room or in another room, to be considered as dangerous, and separated from engine and boiler room by gas-tight bulkheads.
(2) Electric, internal combustion and steam (when the steam temperature is higher than 220°C) prime movers of pumps, of separators (if any), etc., shall be fitted in the engine room or in another non-dangerous room. Where drive shafts pass through pump room bulkhead or deck plating, gas-tight glands are to be fitted by **Ch 1, 1002. 1** (1) (b).

7. Pumps

(1) Pumps shall be fitted with a pressure relief by pass from delivery to suction side
(2) It shall be possible to stop them by a remote control placed in a position near the boiler fronts or machinery control room and from outside the engine room.

8. Electrical equipments

Electrical equipments installed in gas dangerous areas is to be applied in **Ch 1, 1103.** of the Rules.

9. Piping systems

(1) The minimum thickness of the piping for crude oil or slops and draining pipes for the tray defined in a (2) are to comply with the **Pt 5, Ch 6, 102. 6** of the Rules.
(2) The piping connections are to be reduced to a minimum. For the piping connections are to be fitted inevitably, it is to comply with the **Pt 5, Ch 6, 104.** of the Rules.
(3) Within the engine room and boiler room these pipes are to be fitted within a metal duct. This duct is to be specified in the following requirement.
  (A) It is to be gas tight and tightly connected to the fore bulkhead separating the pump room and to the tray specified in **4.** (2).
  (B) It is to be at an inclination rising towards the boiler so that the oil naturally returns towards the pump room in the case of leakage or failure in delivery pressure.
  (C) This duct is to be fitted at a distance from the ship's side of at least 20 % of the vessel's beam amidships.
  (D) It is to be fitted with inspection openings with gas tight doors in way of connections of pipes within it, with an automatic closing drain-trap placed on the pump room side, set in such a way as to discharge leakage of crude oil into the pump room.
  (E) A vent pipe is to be fitted at the highest part of the duct and is to be led to the opening a safe position.
  (F) In way of the bulkhead to which the duct is connected, delivery and return oil pipes are to be fitted on the pump room side, with shut-off valves remotely controlled from a position near the boiler fronts or from the machinery control room. The remote control valves should be interlocked with the hood exhaust fans defined in **4.** (5) (C) to ensure that whenever crude oil is circulating the fans are running.
(4) In the piping to supply with oil to boiler manifold, the remote closing means is to be provided.

10. System for monitoring the concentration of hydrocarbon gases

If the concentration of hydrocarbon gases exceeds 30% of the lower flammable limit. An optical warning device is to be installed near the boiler fronts and in the machinery control room. An acoustical alarm, audible in the machinery space and control room, is to be provided. Gas detector is to be fitted at the following position at least.
(A) Duct defined in **9** (3)

(B) Duct defined in **4** (3)
(C) Near the boiler
(D) All zones where ventilation may be reduced.

11. Fire protection, inert gas generators and steam supply system

(1) Independent of the fire extinguishing plant as required by from **Pt 8, Ch 2** to **Ch 9** of the Rules or Korean Ship Safety Act, an additional fire extinguishing plant is to be fitted in the engine and boiler rooms in such a way that it is possible for an approved fire extinguishing medium to be directed on to the boiler fronts and on to the tray defined in **4** (2). The emission of extinguishing medium should automatically stop the exhaust fan of the boiler hood specified in **4** (5) (C).
(2) The duct specified in **9** (3) is to be permanently connected to an approved inert gas system or steam supply in order to make possible:
(A) In case of fire or leakage
(B) Purging of the duct before carrying out work on the piping in case of leakage.

12. Warning Notice

The following warning notice must be fitted in an easily visible position near the boiler front.
「 **Warning**
When an explosive mixture is signally by the gas detector plant, the watchkeepers are to do as following.
- shut off the remote controlled valves on the crude oil delivery
- return pipes in the pump room,
- inject inert gas into the duct
- turn the boilers to normal running on fuel oil.」⚓

Annex 7-2 Guidance for the Container Securing Arrangements

CONTENTS

1. General
2. Materials and testing for fixed container securing fittings
3. Materials and testing for Loose container securing fittings
4. Arrangements for stowage on exposed decks without cell guides
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6. Container securing arrangements for stowage using cell guides
7. Ship structure
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9. Container Lashing calculation program and instrument

Appendix 1 Container Dimensions of each types
Appendix 2 Examples of Specific Route
Appendix 3 Sample Calculation based on equations

1. General

(1) Application

(A) This Annex is to be applied to securing system of 20 ft and 40 ft container in accordance with the requirements of **ISO 668**. And this annex are also to be applied to special type of containers at **Appendix 1** in principle.

(B) Where the securing system is designed and arranged by other than the requirements of this Annex, it is to be in accordance with those defined in **Rules Pt 1 Ch 1. 105.**

(C) Fixed fittings which are part of the container lashing equipment or which may affect the strength of the ship's hull are subject to approval on the basis of the requirements of this Annex. Details of the connection and the supporting ship structure require approval to satisfy the design loads determined in accordance with **Sec 8** or the safe working load of the fixed fitting, as applicable. Drawings are to be submitted showing details of the fittings, the attachment, the local foundations and information about the intended materials and welding.

(D) Containers are to be loaded so as not to exceed the weights and distribution within the stack according to the Cargo Securing Manual. The permissible loading patterns are to be clearly indicated on the Container Securing Arrangement Plan carried on board the ship.

(E) Where it is intended and specified that loose or fixed parts of the container securing system are used for lifting appliance purposes, e,g., pedestal sockets and fittings used for lifting of hatch cover, or twistlocks used for vertical tandem lifting, **Rules & Guidances Pt 9 Ch 2** are applicable. If no approval from lifting aspects is sought, the devices will be considered as part of a container securing arrangement only.

(F) For ships having the class notation Container Ship, an effective breakwater is to be fitted to protect the containers against green sea impact loads. For other ships which are equipped for the carriage containers on deck, protection of the cargo is recommended by the provision of a breakwater. From Fore End to $0.25L_{BP}$, it is recommended that all door ends face aft in order to improve the performance of the container walls to withstand green sea loads.

(G) Improper ship handling related to course and speed or threshold phenomena like parametric rolling can create adverse forces acting on the ship and the cargo which are in excess of the forces determined on the basis of **Sec 8** It is the responsibility of the Master to apply good seamanship in order to mitigate excessive ship motions to reduce forces acting on the cargo stowage arrangements.

(H) Sample calculation based on equations are referred to **Appendix 3**.

(2) Special Features Notation

(A) Where container securing arrangements are fitted, and the design and construction of the system are in accordance with this Annex, the ship will be eligible to be assigned the special features notation **LS**. The container securing arrangements in the Cargo Securing Manual are submitted to the Society for formal approval.

(B) In addition to (A), if the program for lashing calculations is approved by the Society and installed and maintained, the ship will be eligible to be assigned the special features notation **LS(CL)**. The approval procedure of lashing calculation instrument are to be in accordance with **Par 9.**

(C) Where apply the specific route reduction factors, the contents related to the application of the specific route reduction factors to be included in Cargo Securing Manual and the specific route reduction factors are applicable to onboard lashing program, the ship to be assigned the special features notation **LS(CL, RS).**

(D) In relation to (C), if a program capable of calculating the reduction coefficient for an arbitrary route is installed in addition to the above, a special matter **LS(CL, RS+)** should be assigned to the ship concerned. (*2019*)

(E) For the existing ship has not the above Special Feature Notation, this Annex can be applied if owner requests.

(3) Type of Securing systems

(A) Containers are to be secured by one, or a combination, of the following systems. Containers secured by the other method are to be in accordance with the requirements as deemed appropriate by the Society.

(a) Container locking devices

(b) Rod, wire and chain lashing

(c) Buttresses, shores or equivalent structural restraint.

(d) Cell guides

(B) Dunnage is not to be used in associated with approved container securing systems except where forming part of an approved line load stowage specified in **Par 4.** (5)

(4) Plans and information required

The following plans and documents are to be submitted for the approval of the Society.

(A) General arrangement plan showing the disposition and design weights of the containers

(B) Arrangement and detail plans of container securing arrangements

(C) Calculations on the strength of container securing arrangement including the following ship parameters

(a) Moulded draught d_c, vertical centre of gravity (VCG), longitudinal centre of flotation (LCF) and transverse metacentric height(GM)

(b) Design wind speed

(c) Container lashing strength calculations shall be based on the maximum expected GM value during operation and shall be taken as 0.075B. However, it may be calculated by selecting an lower GM value when necessary for the operation of the ship. *(2017)*

(D) Where containers of types other than ISO containers are to be incorporated in the stowage arrangement, the cargo securing manual is to indicate clearly the locations where these containers are stowed. In the case of non-ISO containers, the value of the criteria of strength evaluation should be specified in the he cargo securing manual. The manual is also to indicate the container weights and required securing arrangements for stacks composed entirely of ISO standard containers. (*2019*)

2. Materials and testing for fixed container securing fittings

(1) General

(A) Fixed cargo securing fittings are to be Type approved in accordance with **Guidance for Approval of Manufacturing Process and Type Approval, Etc Ch 3 Sec 25.**

(B) According to Guidance **Ch 4 Sec 10**, production test are to be carried out.

(2) Materials and design

(A) Steel used for the construction of the fixed cargo securing fittings is to comply with the requirements of **Pt. 2 Ch. 1** of the Rules. Where deemed appropriate by the Society, the suitable materials in accordance with the International Standard(ISO), National Standard or equivalent standards may be used. Due account is to be taken of the grade and tensile strength of the hull material in way of the attachment. The chemical composition of the steel is to be such as to ensure acceptable qualities of weldability. Where necessary, tests are to be carried out to establish specific welding procedures.

(B) Where securing arrangements are intended to operate at low ambient temperatures, special consideration is to be given to the specification of the steel.

(C) Proposals for the use of materials other than steel will be specially considered.

(D) Attention is drawn to the need for measures to be taken to prevent water accumulation in pockets or recesses that could lead to excessive corrosion.

3. Materials and testing for Loose container securing fittings

(1) General

(A) Loose container cargo securing fittings are to be Type approved in accordance with **Guidance for Approval of Manufacturing Process and Type Approval, Etc. Ch 3 Sec 25.**

(B) According to Guidance **Ch 4 Sec 10**, production test are to be carried out.

(C) In the following, the term 'Fully automatic fitting' is used to describe fittings which do not require manual operation during unloading of the containers. It should be noted that usually these fittings do not mechanically secure the container in the vertical direction (perpendicular to the hatch cover) in the upright condition when subject to pure vertical motions. Other modes of operation and novel design will be specially considered.

(2) Materials and design

(A) Steel used for loose container securing fittings is to comply with the requirements of **Pt. 2, Ch. 1** of the Rules. Where deemed appropriate by the Society, the suitable materials in accordance with the International Standard(ISO), National Standard or equivalent standards may be used.

(B) Where loose container securing fittings are intended to operate at low ambient temperatures,

special consideration is to be given to the specification of the steel.

(C) Proposals for the use of materials other than steel will be specially considered.

(D) Locking devices and other fittings which are inserted into the container castings on the quayside before lifting on board are to be such as to minimise the risk of working loose under the effects of vibration and the risk of falling out.

(E) For twistlocks, bottom twistlocks, midlocks, stackers with intermediate plates and fully automatic fittings the contact areas, for both tension and compression between the fitting and the corner castings of the containers, are to be such as not to exceed a bearing stress of 300 N/mm^2 under the safe working load of the fitting. No increase in the permissible stress level will be given due to higher strength material of the fittings. In case the design is such that the contact area is sloped or inclined and not parallel to the container corner casting, the effective contact area will be specially considered.

4. Arrangements for stowage on exposed decks without cell guides

(1) General

(A) Containers stowed on deck or on hatch covers are generally to be aligned in the longitudinal direction. In case of stowing the transverse direction it is to be in accordance with the requirements as deemed appropriate by the Society.

(B) Containers are to be stowed so that they do not extend beyond the ship's side. Adequate support is to be provided where they overhang hatch coamings or other deck structures. The stowage arrangements are to be such as to permit safe access for personnel in the necessary working of the ship, and to provide sufficient access for operation and inspection of the securing devices.

(C) Where containers are stowed on hatch covers, the covers are to be effectively restrained against sliding by approved type stoppers or equivalent. Details of the locations of stoppers relative to the supporting structure are to be submitted at as early a stage as possible.

(D) Stanchions and similar structure supporting containers and securing devices such as D-rings for lashings, are to be of adequate strength for the imposed loads and of sufficient stiffness to minimise any deflection which could lead to a reduction in the effectiveness of the securing device.

(E) In general, stowage of heavy containers on top of lighter containers is to be avoided, unless validated as being satisfactory by an approved on-board lashing program or covered by the approved container securing arrangement.

(F) When semi automatic/fully automatic fitting is used for external or vertical lashing, approved fittings for the lashing shall be used. *(2017)*

(a) For fittings where the locking method requires defined clearances between the corner castings and the fixed foundations, such fittings are not to be used at the lowest tier of a stack which is resting with one side on a hatch cover panel and bridging to a container stanchion. The same applies if the stack is resting on different hatch cover panels or foundations where relative deflection during ship operation can occur.

(2) Containers in one tier

The containers are to be secured by one of the following (A) to (B);

(A) Containers are to be secured at their lower corner castings by approved locking devices.

(B) Alternatively, containers may be secured by lashings fitted diagonally or vertically at both ends of each containers, in association with corner fittings at each container corner.

(3) Containers in two tiers

The containers are to be secured by one of the following (A) to (C);

(A) Containers are to be secured at their lower corners at each tier by approved locking devices.

(B) Where the calculations indicate that separation forces will not occur at any point in the stack, double stacking cones may be fitted at all internal corners of the stack and bridge fittings used to connect the tops of the rows in the transverse direction. Locking devices are to be fitted at all external corners.

(C) Alternatively, containers may be secured by lashings in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking device.

(4) Containers in more than three tiers

(A) Containers are to be secured at their lower corners at each tier by approved locking devices.

(B) Alternately containers may be secured by lashings. One or two tiers of lashings may be fitted in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking devices.

(C) When lashings are employed, they are to be fitted to the bottom corner casting of the upper container and not to the top casting of the container below.

(D) Proposals to use lashings in pairs (para-lashing arrangements) will be considered. Lashings in pairs are to be attached one to the bottom corner fitting of the upper tier and the other to the top corner fitting of the lower tier container. Suitable connections are to be provided at the lower ends. External para-lash arrangements are not recommended. If external para-lash arrangements are used, special care should be taken with regard to the interference and tension force of the upper lashing. *(2017)*

(E) Where tiers are fitted at higher levels, they are to be secured by locking devices at each corner and each tier.

(F) Proposals to use horizontal lashings connected to lashing bridges will be specially considered. The forces in such securing systems are to be determined by direct calculations taking into account the following effects:

- stiffness of the container side/end walls, the lashings and the lashing bridge; and
- the possible horizontal displacements of the containers relative to the lashing bridge due to the clearances of the hatch cover stoppers and the container securing fittings.

(G) When vertical lashings are used in combination with container securing fittings, consideration is to be given to the vertical clearances between the fittings and the container corner castings.

(a) The lashing assembly is to remain elastic when subject to an elongation equating to the number of interface fittings fitted below the point where the vertical lashing is applied to the stack. In order to avoid overstressing of the rod and the turnbuckle, provision of spring or elastic elements incorporated into the turnbuckle may be advantageous. When lashing from lashing bridge level, the number of interfaces is to be counted down to the level where the lowest container is resting. The lashing rod is to be fitted to the bottom casting of the container. For container securing fittings having design clearances in accordance with ISO 3874, a nominal clearance per fitting of 10 mm is to be taken to determine the total elongation of the lashing system. For fittings having clearances in excess of 10 mm, the total elongation is to be calculated taking into consideration the higher clearances.

(b) To take into account the load bearing effect of the vertical lashing arrangement when performing lashing calculations, the permissible calculated lifting force can be increased by 150 kN in addition to the safe working load of the container securing fitting. The nominal lifting force is not to exceed 400 kN at the securing fittings below the fitting position of the vertical lashing.

(H) For stowage arrangements incorporating fully automatic fittings which do not mechanically secure the container in pure vertical direction when subject to vertical motions, it is to be ensured that no separation occurs under the load cases specified in **8**.(2)(C) In addition, where exposed stacks are secured with fully automatic fittings without internal cross lashings, provision is to be made to prevent buoyancy forces acting on the container which could disengage the containers. In this case the use of effective side screens is required. Otherwise, the first tier of containers is to be secured by manual or semi-automatic twistlocks.

(I) If the carriage of one or more tiers of 20 ft containers being overstowed with at least one tier of 40 ft containers, so called 'Russian Stow Arrangement' is desired, the following requirements apply.

(a) At the 20 ft gap the containers are to be secured by means of midlocks or full automatic twistlocks, whereas the fore and aft ends are to be secured by twistlocks and if necessary supplemented by lashing rods. *(2018)*

(b) The 40 ft overstow container is to be secured by twistlocks or if necessary with a combination of twistlocks and lashing rods. The stack is to be assessed in a two step procedure as follows:

(i) For location at the 40 ft ends the entire mixed stack is to be considered as a 40 ft stack. The weights of the 40 ft containers are to be considered in the calculations. For the tiers of 20 ft containers, the weight of one 20 ft container is to be taken as the basis for the calculation at each tier.

(ii) For the location of the 20 ft tiers at the mid bay position the assessment is to be carried out as for an unlashed stack. The number of stacks should be determined taking into account the deformation of the hatch cover. The 40 ft overstow container

does not need to be taken into consideration. *(2019)*

(5) Line load stowage

(A) Where the containers are supported on bearers placed to distribute the stackweight as uniform line loads, the following requirements are to be complied with;

(a) The stack is, in general, to comprise a maximum of two tiers of loaded containers.

(b) The load from the upper tier is to be transferred through the container corners. Line loading is not to be used between tiers.

(c) The load on each vertical corner post of the bottom tier, calculated in accordance with **Par 8**, is not to exceed one half of the rated load of the container.

(d) Where the calculations indicate that lifting forces may occur, locking devices are to be fitted at the container corners.

(e) The clearance below the bottom container corner casting is to be such that the stacking cone or equivalent cannot be dislodged under shear loading.

(6) Systems incorporating structural restraint

(A) Containers may be secured by the use of a fixed structure providing permanent buttresses in association with portable frameworks. Proposals to adopt such systems will be considered on the basis of the loads developed in the structure and the corresponding stresses.

(B) The framework or other devices securing the containers are to be aligned with the container corner fittings and any clearance gap is to be kept to the minimum to reduce shifting.

5. Container securing arrangements for underdeck stowage without cell guides

(A) Containers are generally to be stowed in holds longitudinally and the stowing of transverse are to be in accordance with the requirements as deemed appropriate by the Society. The securing arrangements are to be designed on the basis of the most severe distribution of loads which may arise in the container stack.

(B) Containers may be secured by locking devices only or by a combination of locking devices, buttresses, shore or lashings. Containers are, in general, to be restrained at every corner at the base of the stack and at all intermediate levels.

(C) Where stacks consist of one or two tiers only, consideration will be given to the omission of corner locking devices. Containers must, however, be secured by a minimum of two corner locking devices.

(D) Where the calculations indicate that separation forces could occur at any particular level, twistlocks or equivalent means of securing are to be fitted at that level. Elsewhere, consideration will be given to the use of double stacking cones.

(E) Where the calculations indicate that separation forces will not occur between containers at any level, consideration will be given to the use of double stacking cones in lieu of locking devices throughout.

(F) Buttresses are generally to be of the tension and compression type and are to be provided with means of adjustment to ensure tightness when fitted in place. Where applicable, the attachment to the ship's structure is also to include means for vertical adjustment of the buttress to match container stacks of different heights.

(G) Shores of compression only type may be permanently attached to the ship structure or they may be hinged or portable. When in place they are to abut on the container corner fittings with minimal clearance. Means are to be provided to prevent slackening of the device.

(H) Adjacent stacks of containers are to be linked in line with buttresses or shores in order to transmit lateral loads. The fittings used for these linkages are to be of adequate strength to transmit the loads imposed.

(I) The ships structure supporting shores and buttresses is to be reinforced as necessary.

(J) Proposals for alternative securing systems, including systems relying on minimal clearance between containers and hull structure, will be specially considered.

(K) Attention is drawn to the safety at work aspects for fittings which require operation on top of containers, e.g. double stacking cones, bridge fittings, buttresses and shores. Where these fittings are used, fall protection is to be provided.

6. Container securing arrangements for stowage using cell guides

(1) General

(A) Cell guide systems may be fitted to support containers stowed in holds or on exposed decks.

(B) The cell guides are not to form an integral part of the ship's structure. The guide system is generally to be so designed as to keep it free of the main hull stresses.
(C) Cell guides are to be designed to resist loads caused by loading and unloading of the containers, to prevent shifting of the containers and to transmit the loads caused by motions of the ship into the main hull structure.

(2) Arrangement and construction
(A) Cell guides are to have sufficient vertical extent and continuity to provide efficient support to containers. Guide bars are to be effectively attached to the supporting structure to prevent tripping or distortion resulting from container loading.
(B) The intersection between cell guide and cross ties is to provide adequate torsional stability.(See **Fig 1**)
(C) Intermediate brackets are to be fitted to vertical cell guides at suitable intervals.(See **Fig 1**)
(D) The cell guides are to give a total clearance between the container and guide bars not exceeding 25 mm in the transverse direction and 40 mm in the longitudinal direction. The deviation of the cell guide bar from its intended line is not generally to exceed 4 mm in the transverse direction and 5 mm in the longitudinal direction.
(E) Athwartship cross ties are to be fitted between cell guides at a spacing determined from the loading on the guides but, generally, not more than 3.0 m part, wherever possible, cross ties are to be arranged in line with the corners of the containers as stowed and are to be supported against fore and aft movement at a minimum of two points across the breadth of the hold. Where, however, the maximum fore and aft deflection in the cross tie can be shown not to exceed 20 mm, then one support point may be accepted.
(F) Longitudinal tie bars may be required to be fitted where shown necessary by the force calculations for the structure. Where fitted, they are to be specified in (E) above.
(G) Where, at the sides or ends of holds, the guide rails are fitted to transverse or longitudinal bulkheads, the bulkhead is to be locally reinforced to resist the additional loads.

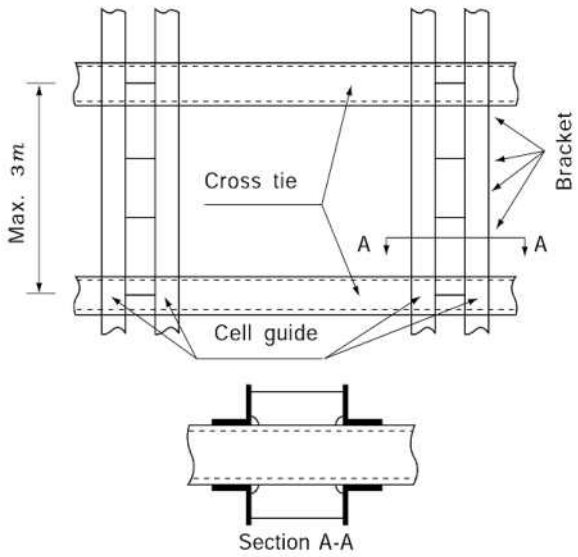


Fig 1 Typical arrangement of cell guides

(3) Cell guide systems on exposed decks
(A) Analysis methods for the strength of the cell guide structure are to take due account of the interactive effects between guide structure and supporting deck structure and also of the deformation of the hull girder.
(B) At its lower end the guide structure is to be efficiently connected to the deck structure. Cross ties are to be arranged between guides in a transverse direction at a spacing determined by the loading on the guides but in general not more than 3 m apart. Cross bracing members of adequate strength and sufficient number are to be fitted in the transverse and longitudinal directions to prevent excessive deflection of the guide structure.
(C) The height of guide bars above the deck is to be sufficient to ensure adequate restraint to

container tiers.

(D) Where the cell guide structure is attached to highly stressed hull or deck elements, such as sheer strake, special attention is to be given to the design of the connection and the grade and quality of steel utilized.

(4) Carriage of 20 ft containers in 40 ft cell guides in holds

(A) Where the cell guides are arranged for the carriage of 40 ft containers, provision should be made for the installation of temporary intermediate cell guides for 20 ft containers. The permanent structure is to be designed such that it is suitable for either loading pattern.

(B) Alternatively, permanent means for the support of 20 ft containers at the mid-length of a cell arranged for 40 ft containers should be considered. Such means may include the following:

(a) A pillar (inboard) and vertical rest bar (on the longitudinal bulkhead) against which the container stack may rest. The pillar is to be supported laterally by the deck structure over and is to be sufficiently stiff to control lateral deflection of the container stacks.

(b) Guide bars supported transversely by slim structure within the gap between containers and with longitudinal ties as necessary.
Details of proposals will be individually considered, taking into account the loads on the support structure and the resulting deflections.

(C) Where it is desired to stow 20 ft containers without external support at the mid-bay location with or without 40 ft overstow, so called 'mixed stowage', arrangements meeting the following requirements are applicable:

(a) In case that 20 ft containers are stowed in cell guides with no 40 ft container overstowed, it can be assumed that 65% of transvers accelration will be applied on cell guide side and 35% will be applied on midbay.

(b) In case that transverse acceleration for 20 ft containers stowed in cell guides with at least one 40 ft container overstowed, it can be assumed that 75% of transvers accelration will be applied on cell guide side and 25% will be applied on midbay. In this case, racking and compression of stack except 40 ft container overstowed are to be verified in accordance with **8.**(4), this Annex.

(c) Means are to be provided to prevent transverse sliding of the bottom of the stacks of 20 ft containers at the mid bay position. This is to be in the form of permanently attached chocks at the inner bottom or equivalent. The design clearance is to be the same as for the cell guides and in accordance with **2.**(D)

(d) Stacking cones are to be fitted at each corner between tiers of the 20 ft containers to prevent transverse and longitudinal sliding. But where stacking cones without flanges are used, the stacking cones should be placed in one or more corners on each cross section of the 20 ft containers. In addition, where a 40 ft container is required to be stowed above 20 ft containers, two stacking cones on each cross section are to be fitted at the ends of the 40 ft container between the 40 ft container and the 20 ft containers. (*2019*)

(e) The 20 ft containers are to have closed steel walls and top (no open frame containers, e.g. tank or bulk containers)

(f) Cones are to be fitted on the inner bottom in way of the cell guides to restrain container movement in the longitudinal direction.

(g) The orientation of the containers is to be such that all front ends or door ends are facing in one direction.

(h) The containers are to be stowed in the hold in block stowage. In general, free standing stacks due to adjacent empty stacks are to be avoided.
Proposals for stowage arrangements other than the above will be individually considered and are to be accompanied by supporting calculations.

(5) Entry guide device

(A) A device to pre-centre the container and direct it into the cell guides is normally to be fitted at the top of the guide bars. Such devices include:
- fixed even peaks;
- fixed high and low peaks;
- 'flip-flop' systems;

but other devices will be considered. The device is to be of robust construction.

7. Container support structure *(2019)*

(1) General

(A) Drawings for lashing bridges, cell guides, container supports and other container support

structures are to be submitted to the Society for approval.

(B) The lower part of fixed container securing system of hatch covers and hull structures should be suitably reinforced

(C) FE(Finite Element) method or Grillage analysis can be used for the strength evaluation. The modeling and evaluation should be of a gross scantling, and the element size should be such that the behavior of the structure can be faithfully reproduced.

(D) The evaluation of the hatch cover strength is to be in accordance with the requirements in **Pt 4, Ch 2** of the Rules.

(E) If a lashing bridge of the Mickey Mouse type is applied, special considerations should be taken to constrain the lateral displacement of the structure.

(F) If requested by the owner or deemed necessary by the Society, vibration evaluation on the lashing bridge can be performed. *(2021)*

(2) Structural strength evaluation

(A) Structure modelling

(a) Model extent

(i) The model for strength evaluation should include at least hull structure until first stringer in vertical direction and one web frame in longitudinal direction from container support structure. Generally both port and starboard of the lashing bridge structure should be modelled.

(ii) Alternatively, the strength evaluation may be performed using only the lashing bridge model. However, strength evaluation for the hull structure in contact with the lashing bridge should be additionally performed by using the reaction force derived from the analysis of the lashing bridge model.

(iii) The strength evaluation of the lashing bridges on fore part, midship and after part should be carried out. And addition strength evaluations may be required when deemed necessary by the Society.

(b) FE model

(i) The FE model follows the right-handed coordinate system as shown in **Table 1.**

Table 1 Coordinate system *(2019)*

Coordinate	Direction	Note
x	longitudinal	positive forwards
y	transverse	positive to port from centerline
z	vertical	positive to upward from base line

(ii) In general, plate elements should be used. *(2020)*

(iii) The element size should be sufficiently small to be able to represent the shape of the structure and to limit stress concentration. In general, the members which have a stress variation in the depth direction should be meshed into 3 sub depths. The minimum required element size of fine mesh area need not be less than the thickness of the plate. *(2020)*

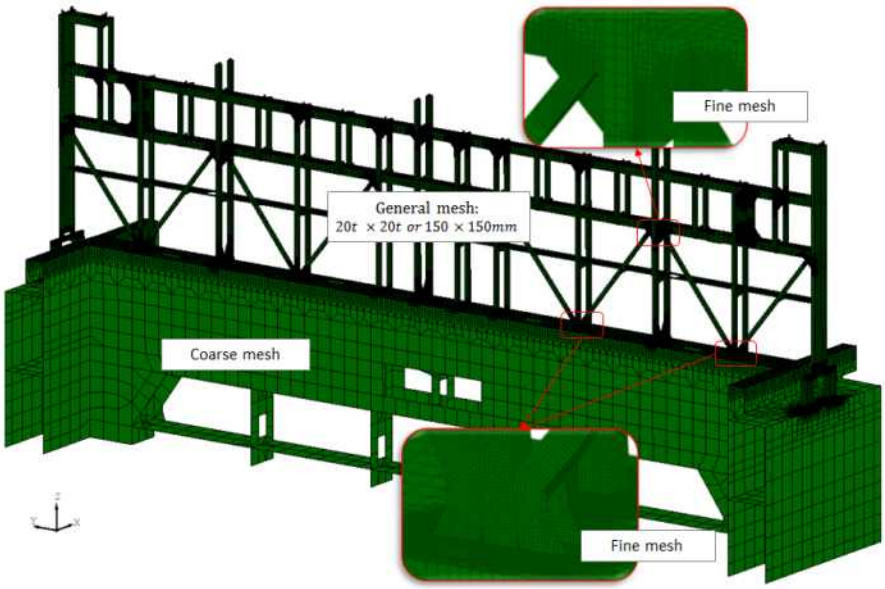


Fig 2 Example of element splitting of lashing bridge *(2019)*

(B) Boundary conditions

A suitable boundary condition that can express the behavior of an actual structure should be applied to the structural model.

(C) Loads

(a) Design loads

(i) For the supporting structure of the container securing system , the safe working load(SWL) of the container securing system can be used as the design loads.

(ii) The design loads can be calculated according to **8.** by applying the container arrangement layout of the container arrangement plan.

(iii) When considering the load, all predictable operating directions should be considered.

(b) Combination of design loads

(i) Lashing bridge

The following combinations of design loads shall be considered:

- containers loaded in both forward and aft bays of lashing bridge(transverse load maximum condition)
- containers loaded in the forward bay of the lashing bridge(forward direction maximum load condition)
- containers loaded in the aft bay of the lashing bridge(aft direction maximum load condition)

The design loads should be the value calculated according to the container stowage arrangement. Where SWLs are used as design loads, the values shown in **Fig 3** can be used.

(ii) Cell guide

The design load combination shown in **Table 2** below should be considered and the conditions for loading the high cubic container should be considered. For cell guides installed on the deck, wind loads should be taken into account.

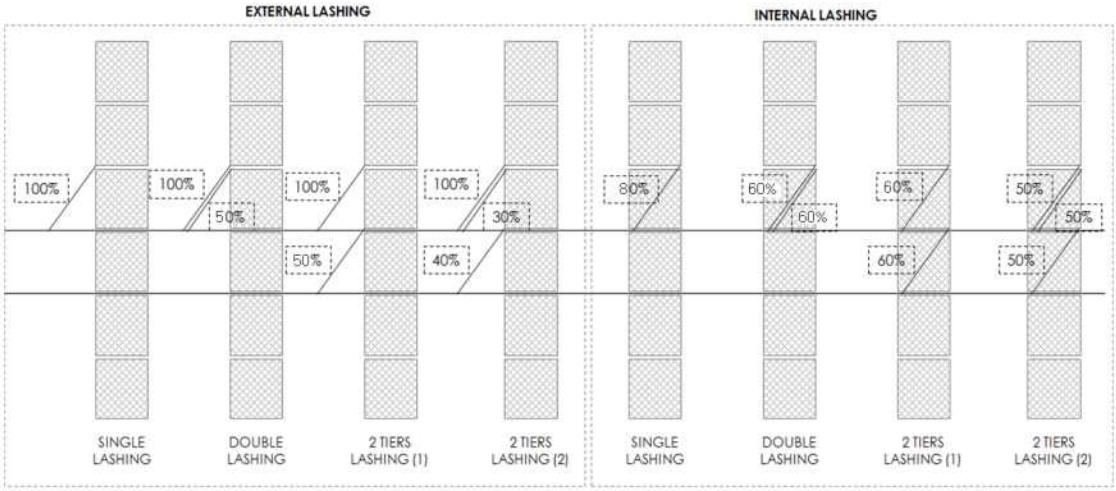


Fig 3 Examples for load distribution of SWLs as design loads *(2021)*

Table 2 Design load combination of cell guide *(2019)*

Load condition	Transverse load	Longitudinal load	Vertical load
Load combination 1	apply	not apply	not apply
Load combination 2	not apply	apply	not apply

(iii) Container stanchion
The design load combinations in **Table 3** below should be considered. For container stanchion in the outermost stack, the wind loads should be considered.

Table 3 Design load combination of container stanchion *(2019)*

Load condition	Transverse load	Longitudinal load	Vertical load
Load combination 1	apply(inside)	not apply	apply(tension)
Load combination 2	apply(outside)	not apply	apply(compression)

(iv) Other container support structures
It shall be deemed appropriate by the Society.

(D) Permissible stress
(a) Stresses of container support structures are not to exceed the permissible values given in **Table 4**.

Table 4 Permissible stress values *(2019)*

Stress	Permissible stress (N/m^2)
Normal stress (bending, tension, compression)	0.8 σ_0
Shear stress	0.46 σ_0
Combined stress	0.9 σ_0 (1)
σ_0 : specified minimum yield stress (N/m^2) (1) : The permissible stress may be alleviated up to 1.2 σ_0 for stress concentration part of fine mesh area.	

(E) Buckling strength

(a) The buckling strength evaluation should be performed for the members with stress derived from the FE analysis according to **Pt 14, Ch 8** of the Rule.

$\eta_{act} < \eta_a$

η_{act} : Buckling usage factor obtained from **Pt 14 Ch 8 Sec 5 2.2.1** and **3.1** of the Rule

η_a : allowable buckling usage factor

plate of platform : 0.9

strut and piller : 0.67

(F) Stiffness of lashing bridge

(a) The maximum transverse displacement of the lashing bridge load operating point should not exceed the following values;

- 1 tier lashing bridge : 10 mm
- 2 tier lashing bridge : 25 mm
- more than 3 tier lashing bridge : 35 mm

(3) Vibration analysis

(A) FE model

(a) The lashing bridge should be properly designed so that the natural frequencies of the structure avoid resonance with the excitation frequencies of the engine and the propeller.

(b) Where the ship is expected to operate with no containers secured to the lashing bridges, such as during sea trials, ballast voyages or empty on deck bays, the vibration evaluation of the lashing bridge should be considered.

(c) In general, FE model used for the strength assessment may be used. The vibration response of the lashing bridge should be assessed at several locations, among the vessel. In particular, the lashing bridge of the aftermost part is more likely to vibrate because it is close to the propeller and main engine compartment, so the vibration response should be evaluated.

(d) The structure modelling and boundary conditions for vibration evaluation are described in (2) (A) and (B). Where a global hull structure FE model is available and a global hull modal analysis is to be carried out, it is recommended that the lashing bridge models are incorporated in the global hull structure model prior to vibration analysis.

(B) Natural frequency assessment

(a) The calculated natural frequencies of the global behaviour of the lashing bridge are to satisfy the following requirements:

(i) For lashing bridge structures located aft of the main machinery space, the calculated natural frequencies of the lashing bridge should not be in the range of the propeller blade frequencies associated with:

- lower limit : 80% of NCR minus 10% of MCR
- higher limit : MCR plus 10% of MCR

where,

NCR : the Normal Continuous Rating. In the event that the ship is expected to operate for a prolonged period at a speed lower than that provided by operating at the NCR, then the shaft speed consistent with that speed should be used instead of the NCR.

MCR : the Maximum Continuous Rating

(ii) For lashing bridge structures adjacent to the engine room of ships with slow speed diesel engines, the calculated natural frequencies should not be in the above range for frequencies associated with large engine forces.

(b) A Campbell diagram may be used to assess the potential resonant frequencies. An example Campbell diagram is shown in **Fig 4**. At the intersection between the first order propeller blade frequency line and the line of natural frequencies of a mode, a possible resonant condition can be found.

(c) In order to reduce excessive vibration response due to resonance, it may be considered to apply measures such as additional structural damper system, temporary messes or the equivalent. Such measures should be discussed with the Society.

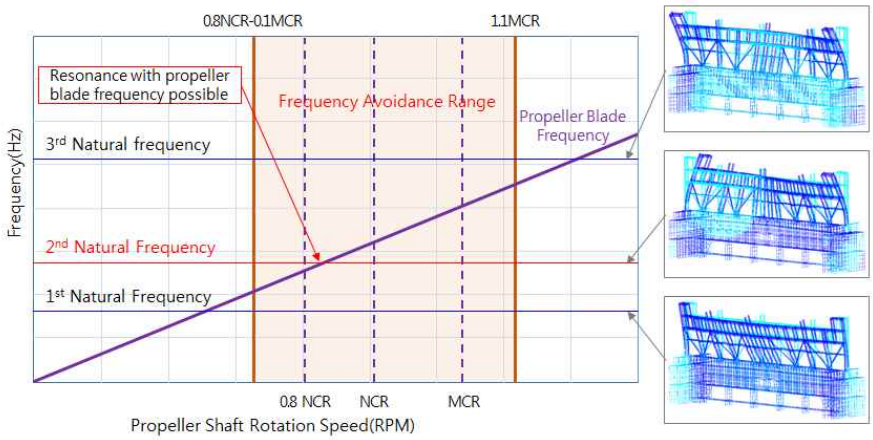


Fig 4 Campbell diagram for Lashing Bridge vibration frequency assessment *(2019)*

8. Determination and application of forces

(1) Symbols and definitions *(2019)*

(A) Definitions and symbols of terms are as follows.

a_0 : acceleration coefficient, is as following formulae

$$a_0 = (1.58 - 0.47C_B)\left(\frac{2.4}{\sqrt{L_{BP}}} + \frac{100}{L_{BP}} - \frac{600}{L_{BP}^2}\right)$$

a_{heave} : acceleration of ship heave motion. is as following formulae

$$a_{heave} = 0.5 f_h a_0 g \ (\mathrm{m/sec^2})$$

a_{sway} : acceleration of ship sway motion, is as following formulae

$$a_{sway} = 0.29 a_0 g \quad (\mathrm{m/sec^2})$$

a_{surge} : acceleration of ship surge motion, is as following formulae

$$a_{surge} = 0.18 a_0 g \quad (\mathrm{m/sec^2})$$

a_{roll} : acceleration of ship roll motion, is as following formulae

$$a_{roll} = \theta\left(\frac{2\pi}{T_\theta}\right)^2 \quad (\mathrm{m/sec^2})$$

a_{pitch} : acceleration of ship pitch motion, is as following formulae

$$a_{pitch} = \left(\frac{3.1}{\sqrt{gL}} + 1.4\right)\phi\left(\frac{2\pi}{T_\phi}\right)^2 \quad (\mathrm{m/sec^2})$$

a_i : distance between center of container corner casting (m), (see **Fig 5**)

a_x, a_y, a_z : acceleration of x, y, z -direction ($\mathrm{m/sec^2}$)

b_i, c_i : length and height of the i-th container (m), (see **Fig 5**)

d_i : height of the i-th container fitting between containers in way of vertical direction (m), (see **Fig 5**)

e_i : The horizontal gap between the container and the lashing bridge (mm)

e_i = 0 : without lashing bridge,

e_i = 700 ~ 1,300 : with lashing bridge

f_h, f_p, f_r : route specific reduction factor for heave, pitch, roll motion, (see **Table 8**)

g : acceleration due to gravity and is to be taken as 9.81 $\mathrm{m/s^2}$

h_i : $c_i + d_i$, (see **Fig 5**)

i : index of i-th container in way of vertical direction

k_r : radius of roll gyration(m), generally 0.35B

ℓ_i : length of lashing device at the bottom of i-th container (mm)

$l_i = \sqrt{a_i^2 + c_i^2 + e_i^2}$

n : number of total tiers in a row

x : longitudinal horizontal distance from afterward perpendicular to the centre of the container (positive forwards) (m), center of local container is 1/2 of container's length.

y : transverse horizontal distance from the centre line of the ship to the centre of the container (positive to portside) (m), center of local container is 1/2 of container's breadth.

z : vertical distance from base line to the centre of gravity of the container (positive upwards) (m), center of local container is 1/3 of container's height.

A_i : area of lashing device at the bottom of i-th container ($\mathrm{mm^2}$)

C_{XS}, C_{YS}, C_{ZH}, C_{YR}, C_{ZR}, C_{XP}, , C_{ZP} : dynamic motion combination factor of each ships' motion, (see **Table 5**)

C_c : height ratio of container weight, generally, 0.45

C_{YG} , C_{XG}: dynamic motion combination factor for roll, pitch motion, (see **Table 5**)

C_{yf}, C_{zf} : dynamic coefficient for at the location of x-direction, (see **Table 7**)

E_i : elongation of lashing rod at the bottom of i-th container ($\mathrm{kN/mm^2}$)(see **Table 10**)

GM : metacentric height (m).

K_i : a transverse stiffness of lashing rod at the bottom of i-th container, is as following formulae

$$K_i = \frac{E_i A_i \cos^2\theta_i}{\ell_i}$$

K_c : spring constant of container's wall (see **Table 9**)

L_{BP} : length between fore and after perpendiculars of the ship (m)

R : centre of motion, to be taken on the centreline at the longitudinal centre of flotation of the ship above the keel, $R = \frac{1}{2}(0.35B + 1.4T_{LC})$

CR : the rating, or maximum operating gross weight for which the container is certified, and is equal to the tare weight plus payload of the container (ton)

T_{LC} : moulded draught in the container load condition (m)

T_i : tensile load of lashing device at the bottom of i-th container

T_θ, T_ϕ : full period of pitch and roll of the ship (sec)

V_w : wind speed (m/sec). For ships with an unrestricted worldwide service area notation a wind speed of 36 m/sec is to be applied at least.

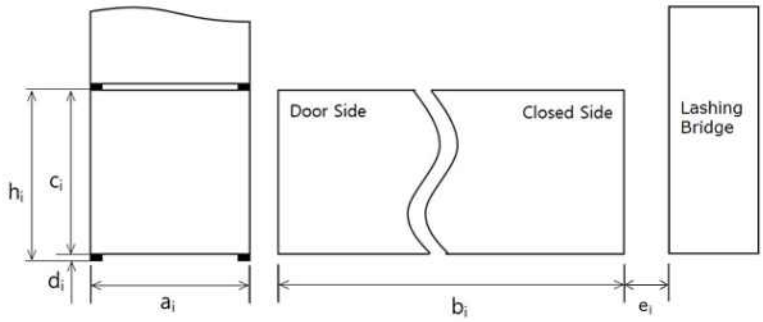
W_i : design weight of the i-th container and contents (ton). In general W_i is to be taken as R (rating weight) unless reduced maximum weights are specified. The following minimum weights W are to be used:

20 ft container : 2.5 ton
40 ft container : 3.5 ton
45 ft container : 4.0 ton

α : coefficient of wind force, (see **Table 5)**

θ_i : lashing angle of lashing device at the bottom of i-th container, (see **Fig 9)**

θ, ϕ : Angle of roll (radian), angle of pitch (radian)



〈Front〉 〈Side〉

Fig 5 Dimension of container

(2) Acceleration of ship motion *(2019)*

(A) The following six dynamic motion cases are to be considered;

BSRL : Roll motion in beam sea
BSHA : Heave acceleration in beam sea
OSPH : Pitch motion in oblique sea

For each dynamic motion case, combination factors, shown in **Table 5**, are used for to calculate the acceleration.

(B) The ship motion angle and period for roll and pitch motions are given in **Table 6.** The accelerations, as below, are to be used to derive the forces for the container securing arrangements. Alternatively, the ship motion values may be derived by direct calculation methods using the same principles as those used to derive the Rule equations. The dynamic coefficients, C_{yf} and C_{zf}, are shown in **Table 7** considering influence of location in x-direction.

$$a_x = -C_{XG}\, g \sin\phi + C_{XS}\, a_{surge} + C_{XP}\, a_{pitch}(z-R)$$

$$a_y = C_{YG}\, g \sin\theta + C_{yf} C_{YS}\, a_{sway} - C_{yf} C_{YR}\, a_{roll}(z-R)$$

$$a_z = -g + C_{zf}\, C_{ZH}\, a_{heave} + C_{zf}\, C_{ZR}\, a_{roll}|y| - C_{zf}\, C_{ZP}\, a_{pitch}(x-0.45L)$$

(C) The sea route specific reduction factors for each dynamic component are shown in **Table 8.** The route specific reduction factor is derived from the long-term response analysis with design life 20 years for the various container ship hull form considering environmental con-

ditions on the route. If route pattern is extraordinary, the factor may be determined in consultation with the Society. Specific route examples refer to **Appendix 2.**

(D) Wind forces are generally to be based on a maximum wind speed of 36 m/sec. Wind forces are to be applied increasing ways of transverse force.

(E) If a 40ft container is loaded on the outermost stack and 40ft / 45ft / 48ft / 53ft container is loaded on the inner stack, the wind forces on the longitudinal protrusion is not applied. If only one 20ft container is loaded on the outermost side and the 40ft / 45ft / 48ft / 53ft container is loaded on the rear, 40ft / 45ft / 48ft / 53ft containers will have 50% wind load.

(F) If the height difference between the top of the container to which the wind forces are applied and the center of the container of the inner stack is less than 1.9 m, wind forces are not applied. For the top container on the inner stack, a wind forces of 80% is to be considered. (refer **Fig 6)**

Table 5 Dynamic motion combination factor *(2019)*

		Acceleration					Angle		Wind
		Surge	Sway	Heave	Roll	Pitch	Roll	Pitch	
		C_{XS}	C_{YS}	C_{ZH}	C_{ZR}, C_{YR}	C_{XP}, C_{ZP}	C_{YG}	C_{XG}	α
BSRL	1	0	0.1	-0.1	-1.0	0	1.0	0	1.0
	2	0	-0.1	0.1	1.0	0	-1.0	0	-1.0
BSHA	1	-0.1	-0.6	-1.0	0.15	-0.1	-0.1	0	-1.0
	2	0.1	0.6	-1.0	-0.15	0.1	0.1	0	1.0
OSPH	1	-0.6	0.4	-0.4	-0.1	-1.0	0.1	1.0	0.5
	2	0.6	-0.4	-0.4	0.1	1.0	-0.1	-1.0	-0.5

Table 6 Ship motions *(2019)*

Motion	Angle of radian	Periods (sec)
Roll	$\theta = f_r \frac{9000(1.25-0.025\,T_\theta)}{(B+75)\pi}$ but need not exceed 30°(0.524 rad) - if $B < 40\text{m}$, not to be taken less than $f_r \times 22^\circ\ (fr \times 0.384 rad)$ - if $B \geqq 60\text{m}$, not to be taken less than $f_r \times 18^\circ\ (fr \times 0.314 rad)$ (If the B is a median value, θ is determined by linear interpolation)	$T_\theta = \frac{2.3\pi k_r}{\sqrt{g\,GM}}$
Pitch	$\phi = f_p 1350\, L^{-0.94}\left\{1.0+\left(\frac{15}{\sqrt{gL}}\right)^{1.6}\right\}$	$T_\phi = \sqrt{\frac{2\pi L}{g}}$

Table 7 Dynamic coefficient at the location of x-direction *(2019)*

x-location (x/L_{BP})	C_{yf}	C_{zf}
0.0	1.63	1.11
0.1	1.46	1.11
0.2	1.32	1.05
0.3	1.24	1.04
0.4	1.20	1.02
0.5	1.20	1.06
0.6	1.23	1.18
0.7	1.30	1.29
0.8	1.39	1.40
0.9	1.52	1.40
1.0	1.68	1.40
The interpolation is to be applied considering x-coordinate belong to each range.		

Table 8 Specific sea route reduction factor *(2018)*

Route	f_r	f_p	f_h
Asia-Europe service	$-0.0035B+1.015$, max 0.928	0.894	0.927
Pacific service	$-0.0058B+1.159$, max 1.00	0.906	1
Pacific-Atlantic service	$-0.0022B+1.036$, max 0.983	0.973	0.996
North Sea-Mediterranean Short Sea service	$-0.0033B+1.056$, max 0.974	0.945	0.968
North Atlantic service	1	1	1
Asia-South America(West Coast)	$-0.0035B+1.046$, max 0.959	0.915	0.991
South America(East Coast)-Africa	$-0.0014B+0.933$, max 0.897	0.867	0.886
Africa-East Asia	$-0.0005B+0.933$, max 0.921	0.909	0.898
Europe(Rotterdam)-Africa	$-0.0019B+0.985$, max 0.936	0.931	0.931
Europe(Rotterdam)_South America(Brazil)	$-0.0019B+1.005$, max 0.957	0.956	0.941
US(NYC)-South America(Brazil)	$0.0034B+0.913$, max 0.829	0.799	0.842
Asia-Middle East Asia	$-0.0072B+1.14$, max 0.958	0.791	0.885
Intra Asia	$-0.0071B+1.107$, max 0.929	0.729	0891

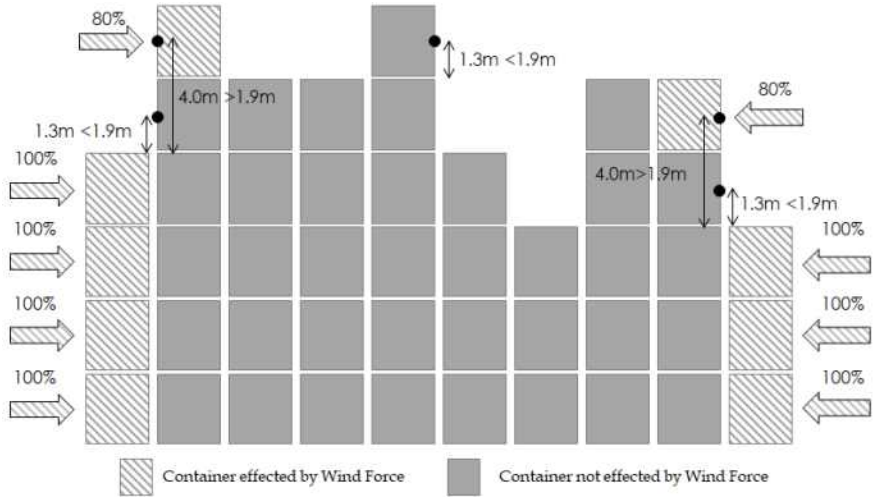


Fig 6 Wind forces applied area *(2019)*

(3) Resultant applied forces for unlashed stack

(A) The resultant forces derived for each container in the stack are assumed to be divided equally between the walls of the container as follows:

H_i : sliding force in one transverse end

$$H_i = a_y \frac{W_i}{2} \text{ (kN)}$$

J_i = sliding force in one longitudinal side

$$J_i = a_x \frac{W_i}{2} \text{(kN)}$$

P_i = vertical force in each corner post

$$P_i = a_z \frac{W_i}{4} \text{(kN)}$$

Q_i = wind force in one transverse end

$$Q_i = \frac{\alpha\, 7.33\, c\, b\, V_w^2 \cos(C_{YG}\Theta) \times 10^{-4}}{2} \text{ (kN)} \qquad (2019)$$

(B) The transverse force at the top of each tier is follows. The subscript i refers to any particular container, see **Fig 7** for example.

$$F_i = C_c H_i + (1 - C_c) H_{i+1} + \frac{Q_i}{2} + \frac{Q_{i+1}}{2} \quad \text{for } i < n$$

$$F_i = C_c H_i + \frac{Q_i}{2} \quad \text{for } i = n$$

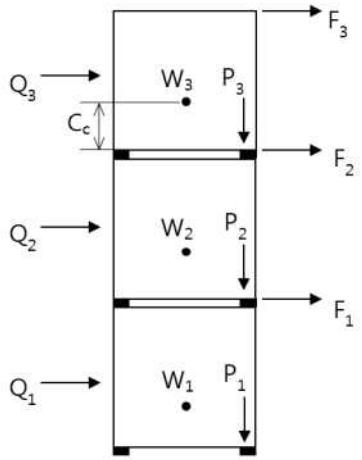


Fig 7 Example of transverse forces for unlashed stack

(C) The equations for the resultant forces in an unlashed stack are listed below;
(a) Racking force, per end wall (kN). see **Appendix 3** for example.

$$Ru_i = \sum_{j=i}^{n} F_j$$

(b) Shear force, per corner (kN), as follows. The same approach applied to the racking force is used to calculate the shear force except of addition of longitudinal sliding force.

$$Su_i = \sqrt{\left(0.55\sum_{j=i}^{n}(H_j + Q_j)\right)^2 + \left(0.55\sum_{j=i}^{n} J_j\right)^2}$$

(c) Compressive force per top and bottom corner (kN) as below. Negative value means compressed force so that absolute value of this force is to be compared with criteria described in **Fig 12** (c). *(2017)*

$$\text{Top} \quad : \; Cu_{i\_top} = \sum_{j=i+1}^{n} P_j - \frac{1}{a_{i+1}} \sum_{j=i+1}^{n} \left(F_j \sum_{k=i+1}^{i} h_k \right)$$

$$\text{Bottom} \; : \; Cu_{i\_btm} = \sum_{j=i}^{n} P_j - \frac{1}{a_i} \sum_{j=i}^{n} \left(F_j \sum_{k=i}^{j} h_k \right)$$

(d) Lifting force per bottom corner (kN) as below. Positive value means lifting force and only positive value is to be compared with criteria described in **Fig 12.**

$$Lu_i = \sum_{j=i}^{n} P_j + \frac{1}{a_i} \sum_{j=i}^{n} \left(F_j \sum_{k=i}^{j} h_k \right)$$

(D) Where the stack is in an unlashed stack condition without any lashing device, the resultant forces calculated from (C) are not to exceed the allowable loads for which the container is suitable, see (6). The lashing devices are to be arranged if the resultant forces are exceeded the allowable criteria. The resultant forces in the securing devices and supports are not to exceed the allowable working loads for which the device has been approved, see **2** and **3.**

(4) Arrangements incorporating lashings
(A) Where the securing arrangements incorporate lashings, proper allowance is to be made for flexibility of the system. For this purpose, the following values may be adopted:
(a) Racking deformation of the container. Full scale testing of containers indicates that values

of the spring constant may be taken as in **Table 9**. The application of only smallest constant is recommended in case of stacking with various size of containers in a bay.

Table 9 Spring constants K_c for containers

Height (m)	Door end (kN/mm)	Closed end (kN/mm)	Side Wall (kN/mm)
2.438	3.7	16.7	6.1
2.591	3.5	15.4	5.7
2.743	3.3	14.3	5.4
2.896	3.2	13.3	5.1

(b) Horizontal movement of the containers:
Initial displacement of containers due to tolerances in container fittings will be considered in conjunction with the stowage arrangement proposed. Generally, initial displacement may be neglected in calculation procedures for conventional stowages.

(c) Elongation of lashings:
Elongation is to be determined by reference to the effective modulus of elasticity of the lashing which, in the absence of actual test values, may be taken as shown in **Table 10**.

Table 10 Elongation of lashing E_i (kN/mm^2)

Type of lashing device	Elastic modulus
Steel rod lashings of hook type turnbuckle	98
Short (one tier) steel rod lashings (knob type), incl. turnbuckle and lashing eyes	140
Long (two tier) steel rod lashings (knob type), incl. turnbuckle and lashing eyes	175
Steel wire rope lashings	90
Steel chain lashings (based on the nominal diameter of the chain)	80
Adjustable tension compression buttress	120

(B) Any other element introducing flexibility into the structure between the lashing point and the base of the container stack is to be evaluated and taken into account, if necessary. Examples of this could be flexibility of a lashing bridge, sliding of a hatch cover, or torsional deformations of the hull.

(C) In the case of a para-lashing arrangement where two lashing rods and two turnbuckles are attached to adjacent corner castings, total cross-section area is set to the sum of each rod section area. In the case of para-lashing arrangement in which one turnbuckle and two lashing rods are used in combination, shown on (**Fig 8**), the same section area is used. *(2021)*

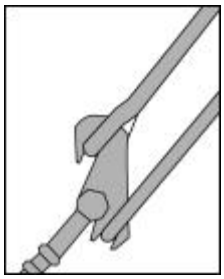


Fig 8

(D) The calculations are to be made for each end of the container stack, that is with all door ends together and with all closed ends together.

(E) For conventional arrangements, the spring constant K_i for the lashing rod at the bottom of i -th container may be determined as shown in **Fig 9**:

$$T_i = \frac{E_i A_i}{\ell_i} \Delta \ell_i = \frac{E_i A_i}{\ell_i} (\delta_i \cos\theta_i)$$

$$T_i \cos\theta_i = \frac{E_i A_i}{\ell_i} (\delta_i \cos\theta_i) \cos\theta_i = \frac{E_i A_i \cos^2\theta_i}{\ell_i} \cdot \delta_i$$

$$K_i = \frac{E_i A_i \cos^2\theta_i}{\ell_i}$$

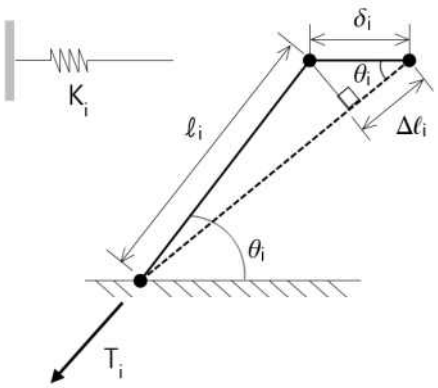


Fig 9 Horizontal stiffness of lashing rod

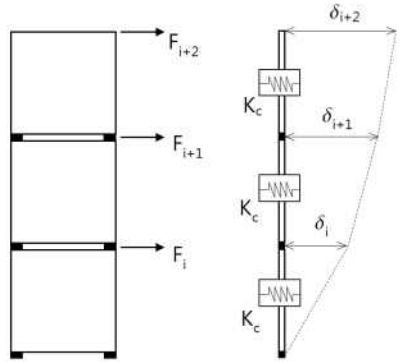
In case of the aforementioned configuration, attention is to be paid to the fact that the arrangement of the fixed lashing plates is to be suitable to accommodate the inclined lashing rods. In addition, attention should be paid to the design of the heads of the lashing rods being suitable to secure the container under the angle of inclination.

(F) A buttress or shore may be modeled in a similar way to a lashing. Where, however, more than one stack is supported by the use of linkages between adjacent containers in line with the buttress or shore, the model is to take this into account.

(G) The resultant applied forces in the lashed condition are determined in accordance with (5). The distribution of forces in the stack is obtained by equating the total movement of the containers with the corresponding component of elongation of the associated support element under the influence of the imposed forces. The transverse forces due to the tensions in the lashing rods is shown in **Fig 10**. These forces are considered the installation of lashing bridge which extend to several tiers height.

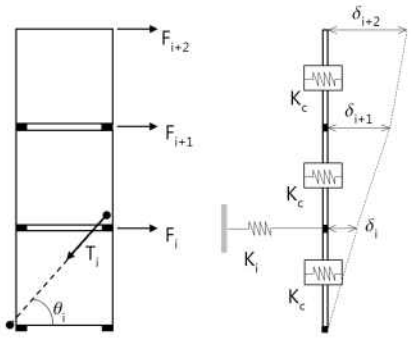
(H) Having established the tension in the lashings, the residual forces in the containers are transmitted through the stack in accordance with the method given in (5). The model assumes that the securing devices between tiers of containers are capable of resisting negative (separation) forces. That is, where separation forces are found, suitable locking devices

are assumed to be fitted and transmitting load.



Unlashed stack

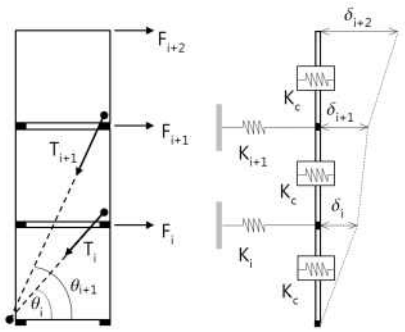
$$\begin{cases} \delta_i = \dfrac{Ru_i}{K_c} \\ \delta_{i+1} = \dfrac{Ru_i + Ru_{i+1}}{K_c} \\ \delta_{i+2} = \dfrac{Ru_i + Ru_{i+1} + Ru_{i+2}}{K_c} \end{cases}$$



Single lashed stack

$$\begin{cases} \delta_i = \dfrac{Ru_i - T_i\cos\theta_i}{K_c} = \dfrac{T_i\cos\theta_i}{K_i} \\ \delta_{i+1} = \dfrac{Ru_i - T_i\cos\theta_i + Ru_{i+1}}{K_c} \\ \delta_{i+2} = \dfrac{Ru_i - T_i\cos\theta_i + Ru_{i+1} + Ru_{i+2}}{K_c} \end{cases}$$

$$T_i\cos\theta_i = \frac{K_i\sum_{k=1}^{i} Ru_k}{K_c + (i\,K_i)}$$



Double lashed stack

$$\begin{cases} \delta_i = \dfrac{Ru_i - T_i\cos\theta_i - T_{i+1}\cos\theta_{i+1}}{K_c} = \dfrac{T_i\cos\theta_i}{K_i} \\ \delta_{i+1} = \dfrac{(Ru_i - T_i\cos\theta_i - T_{i+1}\cos\theta_{i+1}) + (Ru_{i+1} - T_{i+1}\cos\theta_{i+1})}{K_c} \\ \qquad = \dfrac{T_{i+1}\cos\theta_{i+1}}{K_{i+1}} \\ \delta_{i+2} = \dfrac{(Ru_i - T_i\cos\theta_i - T_{i+1}\cos\theta_{i+1}) + (Ru_{i+1} - T_{i+1}\cos\theta_{i+1}) + Ru_{i+2}}{K_c} \end{cases}$$

$$T_i\cos\theta_i = \frac{K_iK_{i+1}\left[\left(\sum_{k=1}^{i} Ru_k\right) - iRu_{i+1}\right] + K_iK_c\sum_{k=1}^{i} Ru_k}{i\,K_i(K_{i+1}+K_c) \;+\; K_c[(i+1)K_{i+1}+K_c]}$$

$$T_{i+1}\cos\theta_{i+1} = \frac{K_{i+1}\left(K_c\sum_{k=1}^{i+1} Ru_k\right) + iK_iK_{i+1}Ru_{i+1}}{i\,K_i(K_{i+1}+K_c) \;+\; K_c[(i+1)K_{i+1}+K_c]}$$

Fig 10 Linear system of horizontal forces for lashed stack

(l) Generally, internal lashings shall be used in case that containers are stowed with lashings. After appropriate verification with Classification, the external lashing as shown in **Fig 11** may be applied for only individual case that the internal lashing can not withstand the greater

forces due to heavier stacks. *(2017)*

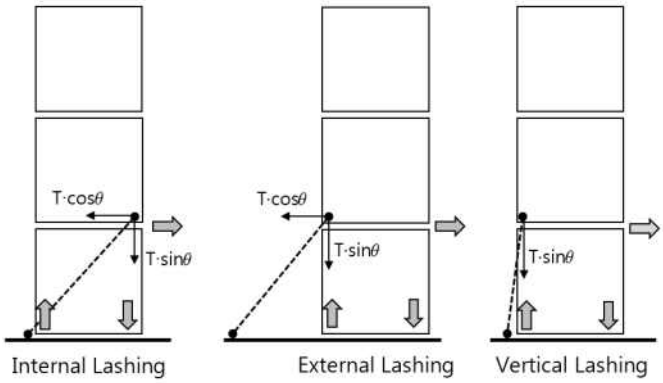


Fig 11 Types of lashing

(5) Resultant forces in an lashed condition

(A) The transverse forces in the containers at the level of the lashing can be calculated similarly in accordance with (3) as below. In case that i-th tier is not lashed condition, tension (T_i) of lashing shall be zero in the calculations.

$$Ft_i = F_i - T_i \cos\theta_i$$

$$Pt_i = P_i - T_i \sin\theta_i$$

(a) Racking force, per end wall (kN).

$$Rt_i = \sum_{j=i}^{n} Ft_j$$

(b) Shear force, per corner (kN), as follows. The same approach applied to the racking force is used to calculate the shear force except of addition of longitudinal sliding force.

$$St_i = \sqrt{\left(0.55\sum_{j=i}^{n}(H_j + Q_j - T_j\cos\theta_j)\right)^2 + \left(0.55\sum_{j=i}^{n} J_j\right)^2}$$

(c) Compressive force per top corner (kN). Negative value means compressed force so that absolute value of this force is to be compared with criteria described in **Fig 12.** *(2017)*

Internal lashing

: $$Ct_{i\_top} = \sum_{j=i+1}^{n} Pt_j - \frac{1}{a_{i+1}}\sum_{j=i+1}^{n}\left(Ft_j \sum_{k=i+1}^{j} h_k\right) - T_i\sin\theta_i$$

External lashing

: $$Ct_{i\_top} = \sum_{j=i+1}^{n} P_j - \frac{1}{a_{i+1}}\sum_{j=i+1}^{n}\left(Ft_j \sum_{k=i+1}^{j} h_k\right)$$

(d) Compressive force per bottom corner (kN). Negative value means compressed force so that absolute value of this force is to be compared with criteria described in **Fig 12.** *(2017)*

Internal lashing

: $$Ct_{i\_btm} = \sum_{j=i}^{n} Pt_j - \frac{1}{a_i}\sum_{j=i}^{n}\left(Ft_j \sum_{k=i}^{j} h_k\right)$$

External lashing

$$: Ct_{i\_btm} = \sum_{j=i}^{n} P_j - \frac{1}{a_i}\sum_{j=i}^{n}\left(Ft_j \sum_{k=i}^{j} h_k\right)$$

(e) Lifting force per bottom corner (kN). Positive value means lifting force and only positive value is to be compared with criteria described in **Fig 12**. *(2017)*

Internal lashing : $Lt_i = \sum_{j=i}^{n} P_j + \frac{1}{a_i}\sum_{j=i}^{n}\left(Ft_j \sum_{k=i}^{j} h_k\right)$

External lashing : $Lt_i = \sum_{j=i}^{n} Pt_j + \frac{1}{a_i}\sum_{j=i}^{n}\left(Ft_j \sum_{k=i}^{j} h_k\right)$

(B) The resultant forces in the containers are not to exceed the allowable values given in (6). The lashing tensions are not to exceed the allowable working loads. The effect of the additional tension by tilting should be taken into account in the top-layer external lashing of the closed ends without doors. However, additional tension may not be taken into consideration when a securing arrangement is used that does not cause additional tension due to application of a spring or the like. *(2019)*

$$\delta v_{act} = F_{NL\_Trigger} / K_{v\_upper\_eff}$$

$$F_{NL\_Trigger} = Lt_{i+1} - T_i \sin\theta_i$$

$$K_{v\_upper\_eff} = C_k \frac{E_i A_i \sin^2\theta_i}{l_i}$$

C_k : nonlinear correction coefficient, is to be as specified by the Society

$\delta v_{\max}$: vertical clearance of twistlock between corner castings, generally 20 mm.

Note 1 In case of fully automatic twistlocks, a functional test report should be submitted to the Society. Where the vertical separation on the test report exceeds 20 mm, the actual value should be applied.

Note 2 If smaller value is to be used, the value may be used in consultation with the Society based on the functional test report.

$$\delta v_{final} = \max(0, \min(\delta v_{\max}, \delta v_{act}))$$

$$T_{i-final} = T_i + \frac{K_{v\_upper\_eff}\delta v_{final}}{\sin\theta_i}$$

After calculating the tension of the uppermost external lashing using the above equation, the tension of the lower external lashing should be recalculated. At this time, the horizontal tension component of the uppermost external lashing is subtracted from the load model, and the horizontal stiffness of the uppermost external lashing is excluded from the stiffness model. Container loads should be recalculated after calculating the tension of all lashing rod. (*2019*)

(C) Where external support is provided by a buttress or shore the load is to be transmitted between adjacent stacks by linkages in line with the support. The force in the transverse end frame members of the containers adjacent to the support is given by:

$$F_b\left(\frac{2N-1}{2N}\right) \text{ (kN) and}$$

the force in the linkage to the adjacent container is

$$F_b\left(\frac{N-1}{N}\right)\ (\mathrm{kN})$$

where,
F_b : calculated force in the buttress or shore (kN)
N : number of rows of containers supported by the buttress or shore.

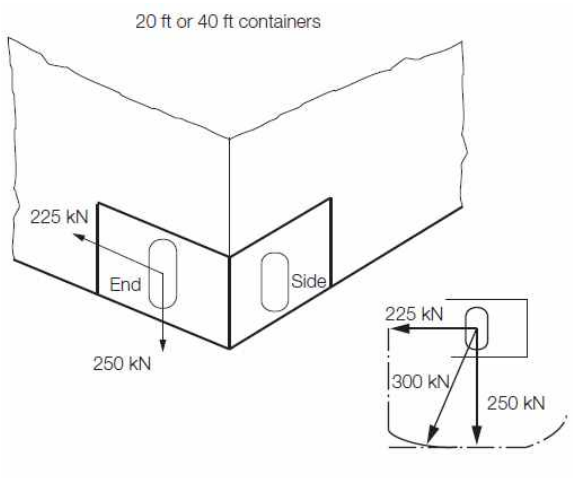
(6) Allowable forces on containers
(A) For ISO containers, the securing arrangements are to be designed so that the forces on the containers do not exceed the values shown in **Table 11**. The maximum forces for ISO 1496-1: 1990 including Amendment Nos. 1, 2 and 3 containers are illustrated in **Fig 12**. Proposals to carry out the lashing calculations for containers manufactured in accordance with ISO 1496-1:1990/Amendment No. 4, 2006 will be specially considered.
(B) Where 45 ft containers in accordance with ISO 1496-1:1990/Amd.4, 2006 are stowed on top of a 40 ft container, the corner post load of the top castings of the 45 ft container are not to exceed a compression force of 404 kN. Consideration should be given to the strength of the container bottom structure to withstand the forces transmitted. No lashings are to be applied to the ends of the 45 ft container if stowed on top of a 40 ft unit.

Table 11 Allowable Load on ISO containers *(2018)*

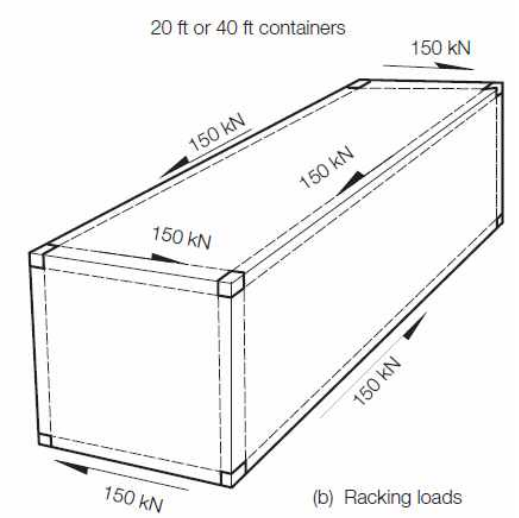
	Allowable Load	
	20 ft (kN)	40 ft (kN)
Horizontal force from a container fitting acting parallel to the side face (See **Fig 12** (b))	150	150
Horizontal force from lashing on container fitting acting parallel to the end face, see Note 1 (See **Fig 12** (a))	225	225
Vertical force from lashing on container fitting acting parallel to the end or side face, see Note 1 (See **Fig 12** (a))	250	250
Racking force on container end (See **Fig 12** (b))	150	150
Racking force on container side (See **Fig 12** (b))	150	150
Vertical forces at each top corner, tension (See **Fig 12** (c))	250	250
Vertical forces at each bottom corner, tension (See **Fig 12** (c))	250	250
Vertical forces at each top corner post, compression (See **Fig 12** (c))	848	848
Vertical force at each bottom corner casting of the lowest container in a stack, compression (See **Fig 12** (c))	848 + (1.8R)/4 see Note 3 & 4	848 + (1.8R)/4 see Note 3 & 4
Transverse forces acting at the level of and parallel to the top face, tension or compression, see Note 2 (See **Fig 12** (d))	340	340
Transverse forces acting at the level of and parallel to the bottom face, tension or compression, see Note 2 (See **Fig 12** (d))	500	500

(Notes)

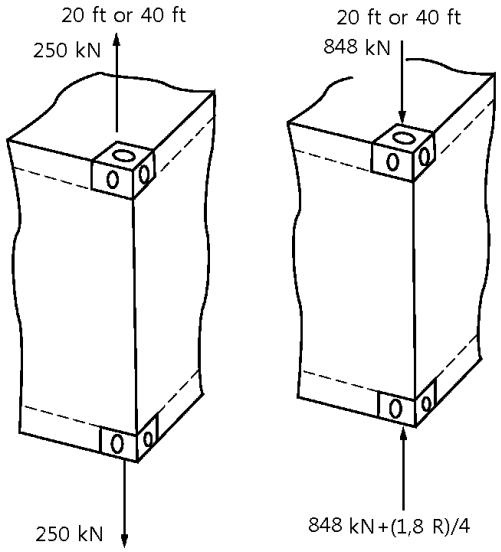
1. In no case is the resultant of the horizontal and the vertical forces to exceed the limiting value derived from **Fig 12** (a). The horizontal and vertical forces are the maximum components of a diagonal force and are not to be used as the maximum load if horizontal or vertical lashings are employed.
2. Where a buttress supports the stack at an intermediate level, the total transverse force in the containers at the level is not to exceed the sum of the appropriate top and bottom forces.
3. The vertical compression force on the lower corner casting on the closed end of the lowest container may exceed 848 + (1,8R)/4 kN, provided the following conditions are complied with:
   (a) The vertical compression force acting on the lowest container from the container above does not exceed 848 kN
   (b) The horizontal racking force acting on the lowest container from the container above does not exceed 150 kN.
   (c) The vertical compressive force acting on the lower corner casting is not exceed the safe working load on the approved certificate for pedestal socket and bottom twistlocks(midlocks). *(2018)*
4. When the container is approved by ISO 1496-1 including amendments up to 2014, 942 kN may be used instead of 848 kN.



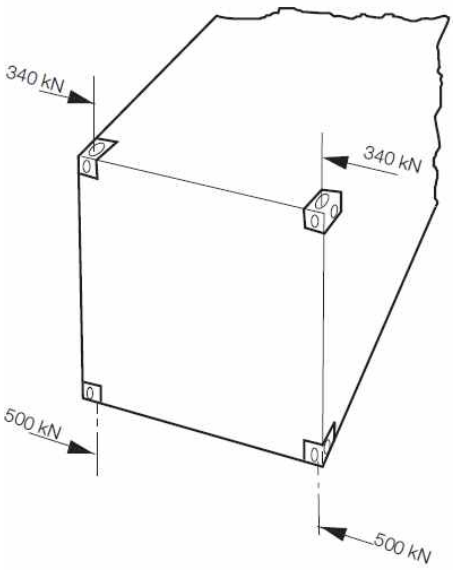
(a) Corner casting lashing loads



(b) 20 ft (40 ft) container, tension or compression



(c) Vertical corner pull-out and compressive forces
(When the container is approved by ISO 1496-1 including amendments up to 2014, 942 kN of load limit may be used instead of 848 kN.)



(d) Transverse compressive forces

Fig 12 Allowable forces for 20 ft or 40 ft containers construced to ISO 1496-1: 1990 including Amendment up to 2014

9. Container Lashing calculation program and instrument

(1) General

(A) The requirements of this Section apply to container lashing calculation system fitted on board for each ships in accordance with the requirements of **Par 1.** (2) of this Annex.

(B) The container lashing calculation system consist of container lashing calculation program(soft-ware) and instrument(hardware).

(C) Container lashing calculation instrument

(a) If requested type approval of lashing calculation instrument, the approval procedure are to

be accordance with **Ch 3 Sec 5** of **Guidance for Approval of Manufacturing Process and Type Approval, Etc**.

(b) Where type approved hardware is installed, one instrument may install, and otherwise two instruments are to be installed.

(c) The onboard lashing calculation program is recommended to be integrated into the loading instrument.

(D) Container lashing calculation program

(a) If requested design approval of lashing calculation program, the approval procedure are to be accordance with **Ch 4 Sec 3** of **Guidance for Approval of Manufacturing Process and Type Approval, Etc**.

(b) Regardless of the design approval to be of the lashing calculation program installed on board ship, Test report for each ships are to be submitted to the Society for approval and on-board installation test for Test report to be carried out.

(c) The test report should include at least the following calculations : *(2017)*

(i) The summary of the maximum load case (racking, shear, compression load, lifting force, lashing tension)

(ii) example of calculation for bay of fore, midship, stern part

(iii) example of calculation for route reduction factor where apply the route reduction factors.

(2) Documentation to submit

(A) If requested approval of lashing calculation program, 3 copies of following documentation are to be submitted to the Society.

(a) User manual

(b) Program description

(c) Test report

(d) Stored ship's characteristic data

(B) All submitted documentation shall be identified with the following :

(a) Name of vessel, name of builder, building number and identification number of the ship

(b) Program name, version number and version date

(c) Program manufacturer and address

(d) List of contents

(C) The documentation are submitted by (A) containing with the following :

(a) User manual

(i) A general description of the program

(ii) A copy of the design approval certificate(if requested design approval)

(iii) Hardware specification needed to run the program

(iv) Listing of error messages and warnings with instructions for actions to be taken by the user in each case

(v) Allowable strength limits with respect to the container, lashing equipment and ship

(vi) Example of calculation procedure supported by illustrations and sample computer output

(vii) Example of computer output of each screen display with explanatory text

(b) Program description

(i) Description of functionality, including flowcharts

(ii) Descriptions of calculation methods and principles

(c) The test report should include at least the following calculations

(i) Typical container stowage in hold

(ii) Mixed stowage, if applicable

(iii) Typical stowage on deck

(iv) Deck stowage with twistlocks only

(v) Case with exceeded stack weight

(vi) Case with exceeded lashing force

(vii) Case with exceeded lifting force

(viii) An example where outboard stack exceeded allowable limits

(d) Stored ship's characteristic data

(i) Main dimensions of the ship

(ii) The position of each bay from the aft perpendicular

(iii) Strength limitations for containers, lashing equipment and the ship

(iv) General loading limitations

(3) Design requirements of container lashing calculation program

(A) The program is to present the following of each container arrangement.
(a) Draught
(b) GM value
(c) Each container weight
(d) Position of each container stack
(e) Lashing arrangement
(f) Accelerations of each container
(g) The calculated load of each container
(h) Strength limitation (according to internal forces in containers, forces in securing equipment and forces in supports)
(i) A clear warning is to be given if any of the strength limitations are not complied with
(j) The data is to be presented as screen and hard copy output to the user in a clear and unambiguous manner
(B) The program is to reject input errors by the user.
(C) The program and the stored characteristic data are to be protected against erroneous use by the user.

(4) The acceptable criteria of the calculation results of the program
The difference of the results of the program calculations with values calculated by the Society is according to the following :

[(Value calculated by program) - (Value calculated by the Society)] / (Allowable) £ ±5%

(5) On-board installation test and approval
(A) The on-board installation test for verify to suitability of lashing calculation program fitted on board and to properly calculated to be carried out under the supervision of the Surveyor.
(B) During the on-board installation test, the output calculated on the installed lashing calculation instrument are to be verified to be identical to the approved Test report and If numerical output is at variance with the approved Test report, a program cannot be approved.
(C) The on-board installation test to be carried out according to all loading condition of approved Test report, at least one of the test conditions is to be built up from the start of calculating procedure, to ensure that the calculating methods function properly.
(D) Where the hardware is not type approved, the test is to be carried out on both the first and the second hardware. Both of the hardwares are to be identified on the certificate.
(E) After completion of satisfactory tests, the lashing calculation system approval certificate is to be issued. The following is to be listed in the certificate :
(a) Name of vessel, name of builder, identification number of the ship and date of built for the ship
(b) Software name, software version
(c) Software manufacturer name and address
(d) Type approval certificate number and design approval certificate number, if relevant
(e) Hardware name, serial number and manufacturer
(f) Identification number of the approved Test report and approval date

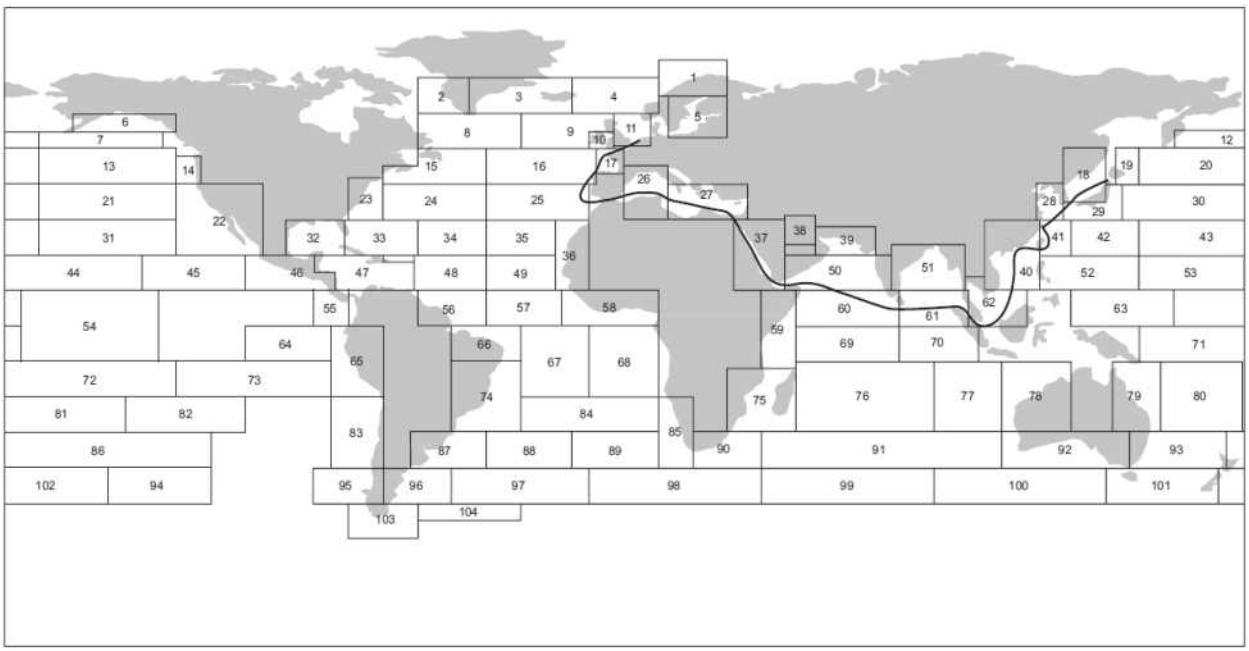
(6) Change of Approval
All changes to the program are to be made by the designer and the Society informed immediately, since such changes invalidate any certificate issued and the certificates shall be re-issued for the changes by the Society.

Appendix 1 Container Dimensions of each types

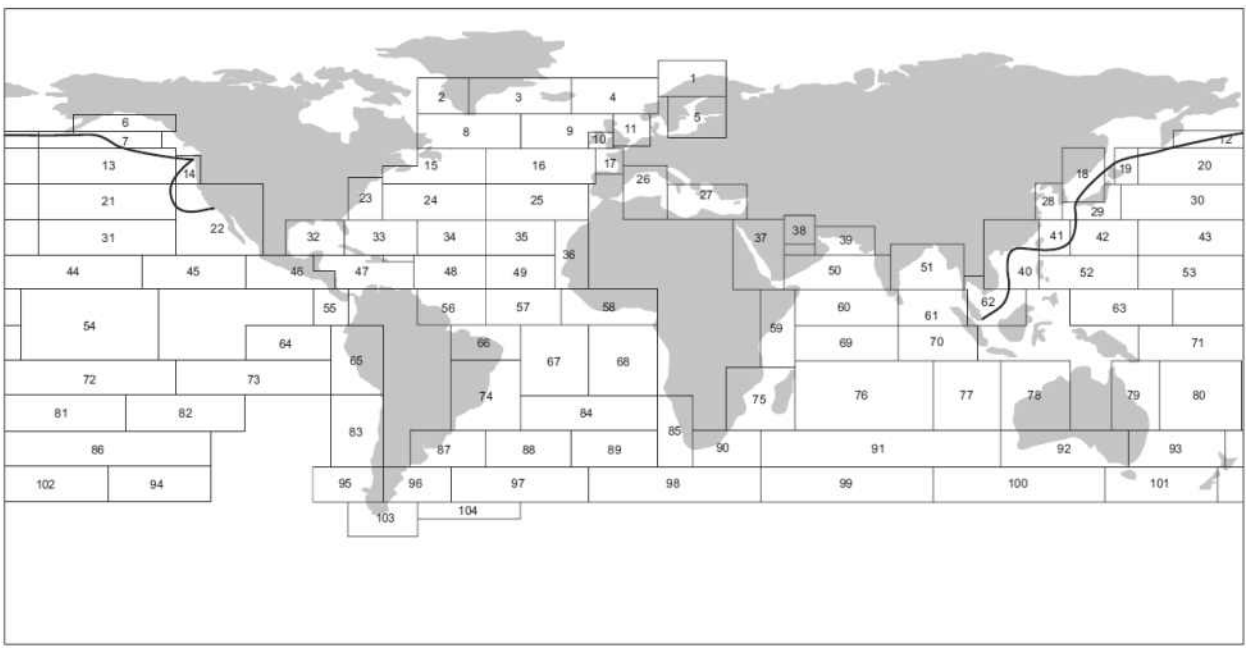
Size	External Dimension						Rating (kg)
	Length		Width		Height		
	(mm)	Tolerance (mm)	(mm)	Tolerance (mm)	(mm)	Tolerance (mm)	
10ft (ISO)	2,991	+0/-5	2,438	+0/-5	2,438	+0/-5	10,160
20ft (ISO)	6,058	+0/-6	2,438	+0/-5	2,438	+0/-5	30,480
					2,591		
30ft (ISO)	9,125	+0/-10	2,438	+0/-5	2,438	+0/-5	30,480
					2,591		
					2,896		
40ft (ISO)	12,192	+0/-10	2,438	+0/-5	2,438	+0/-5	30,480
					2,591		
					2,896		
45ft (ISO)	13,716	+0/-10	2,438	+0/-5	2,591	+0/-5	30,480
					2,896		
48ft	14,630	+0/-10	2,591	+0/-5	2,908	+0/-5	30,480
53ft	16,154	+0/-10	2,591	+0/-5	2,908	+0/-5	30,480

Appendix 2 Examples of Specific Route *(2018)*

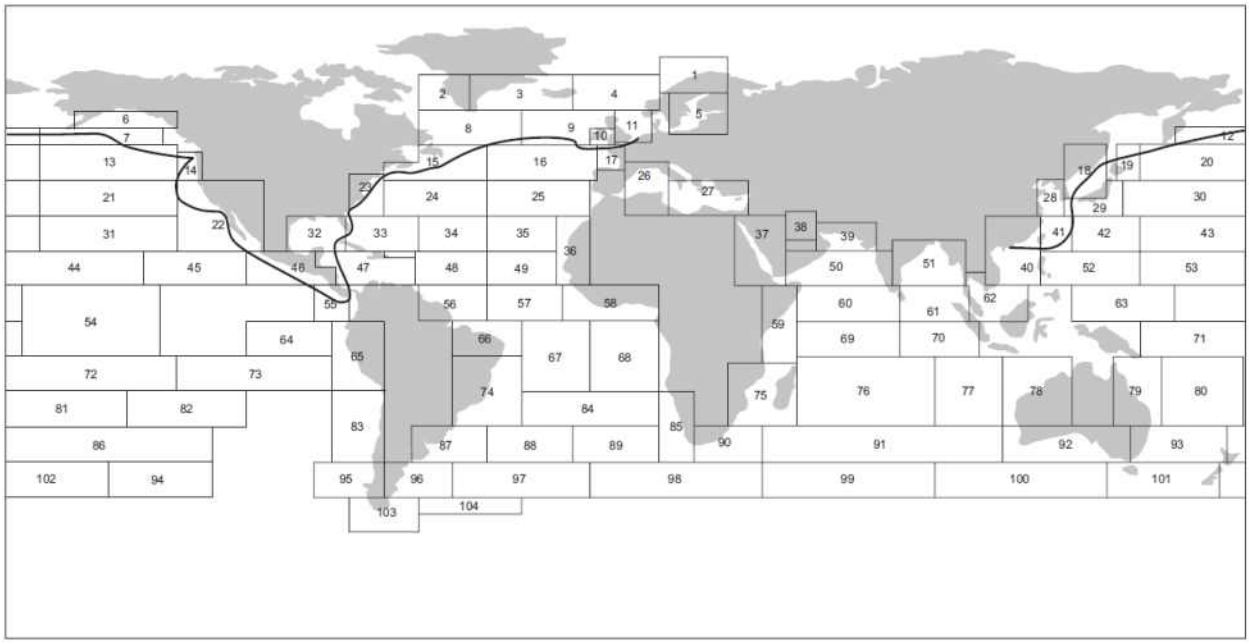
1. Asia – Europe



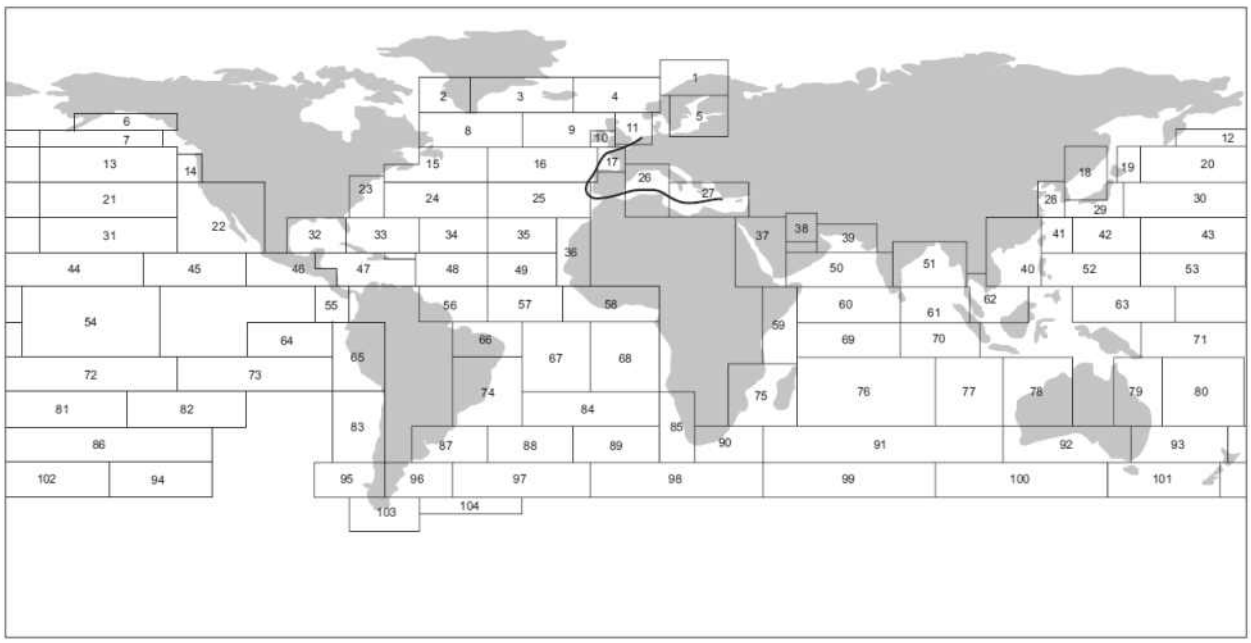
2. Pacific



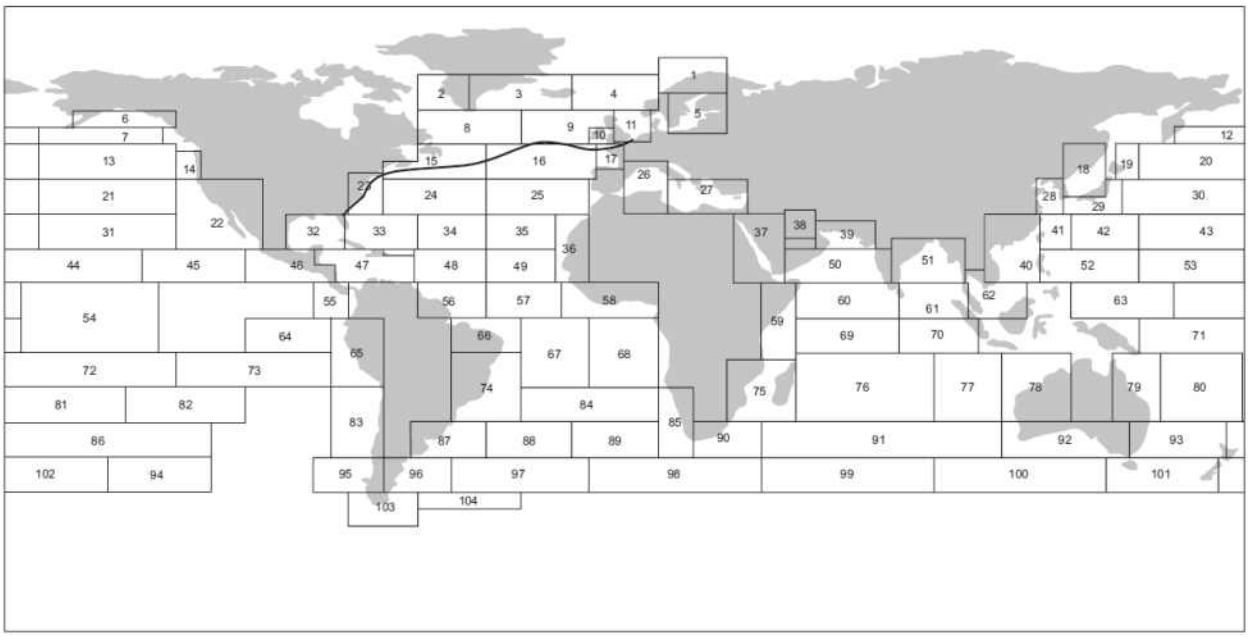
3. Pacific - Atlantic



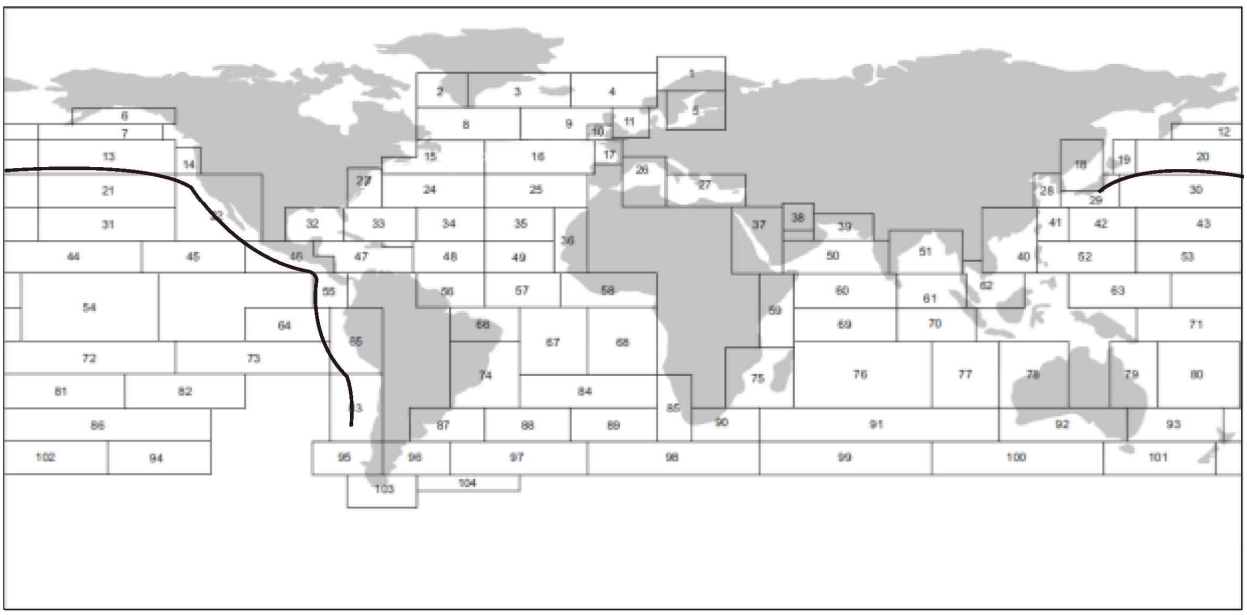
4. North Sea - Mediterranean Short Sea service



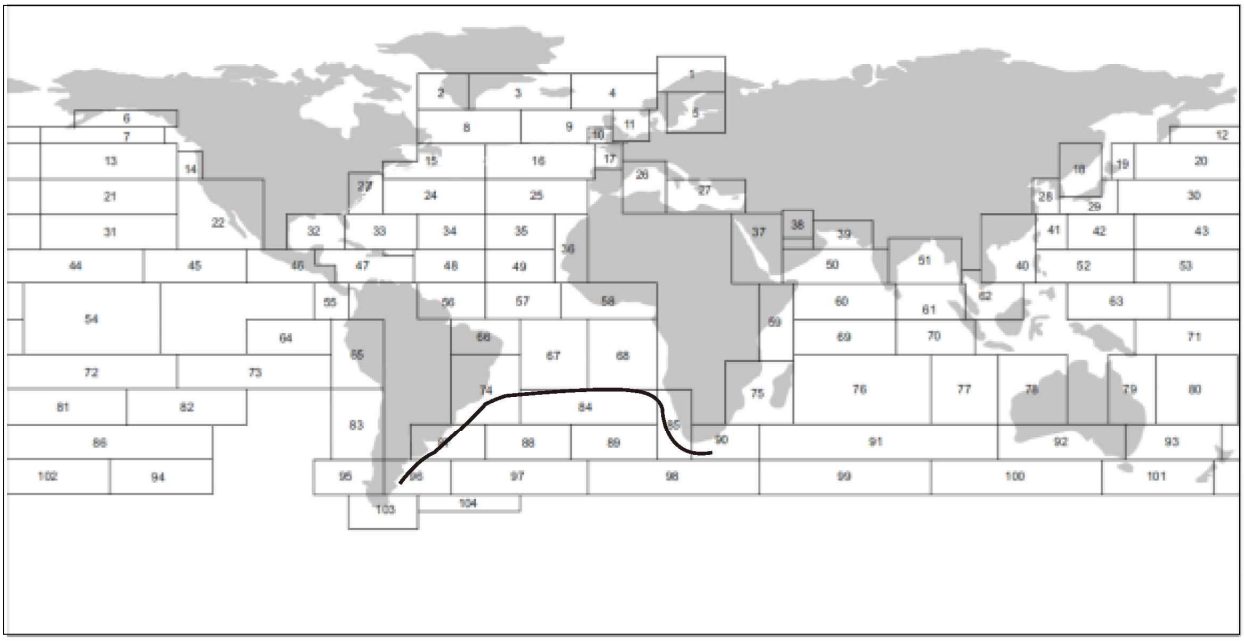
5. North Atlantic



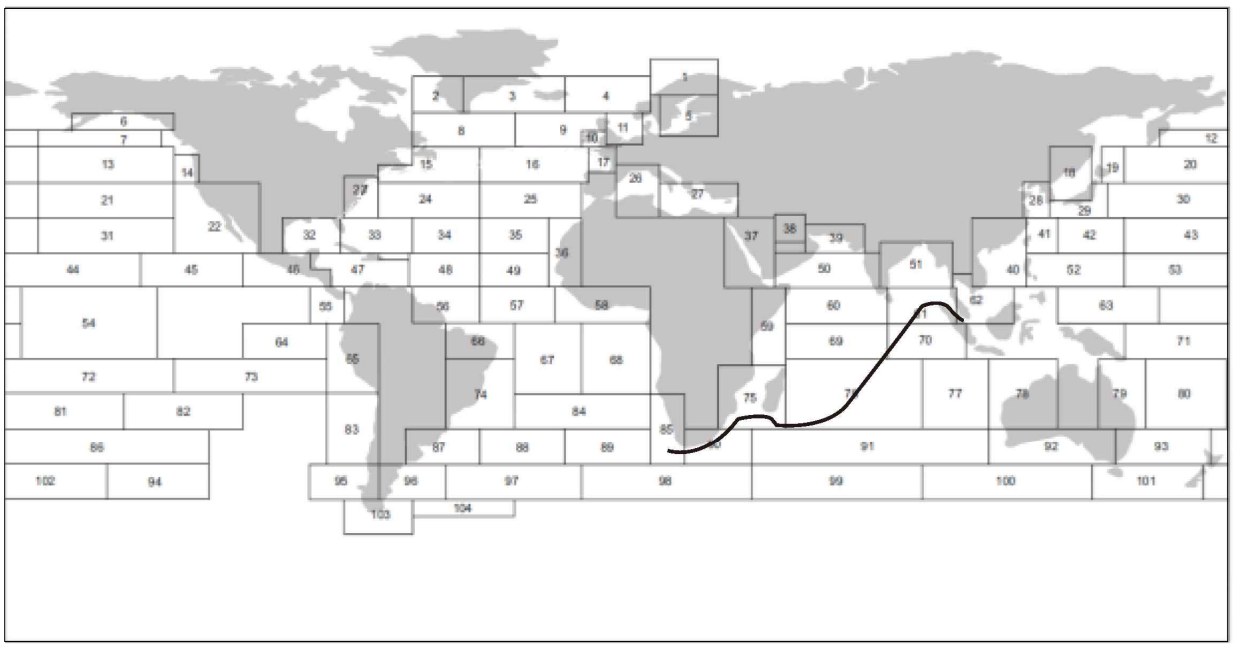
6. Asia – South America (West Coast)



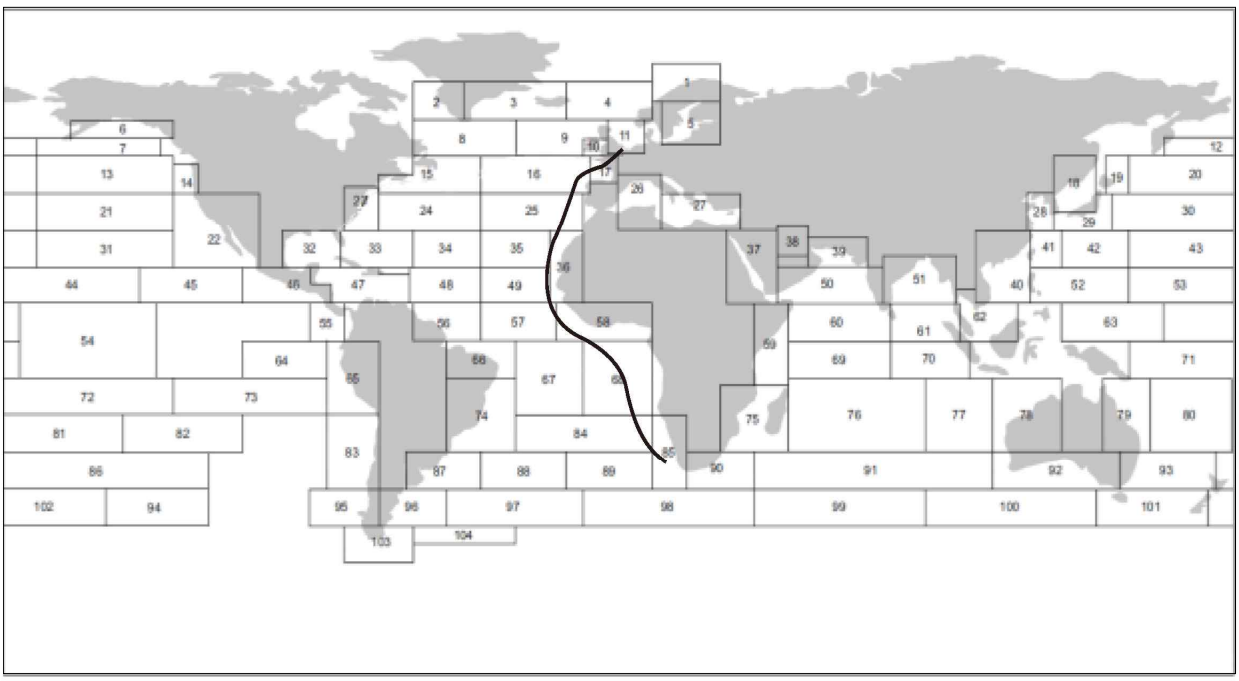
7. South America (East Coast) - Africa



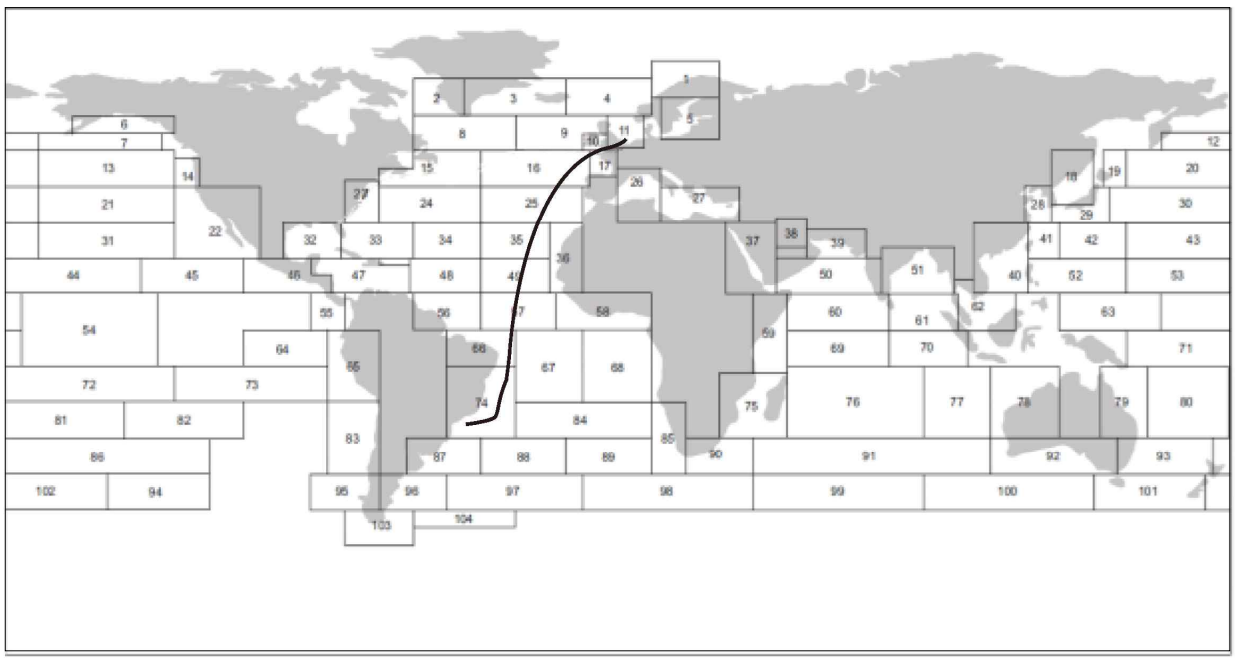
8. Africa - East Asia



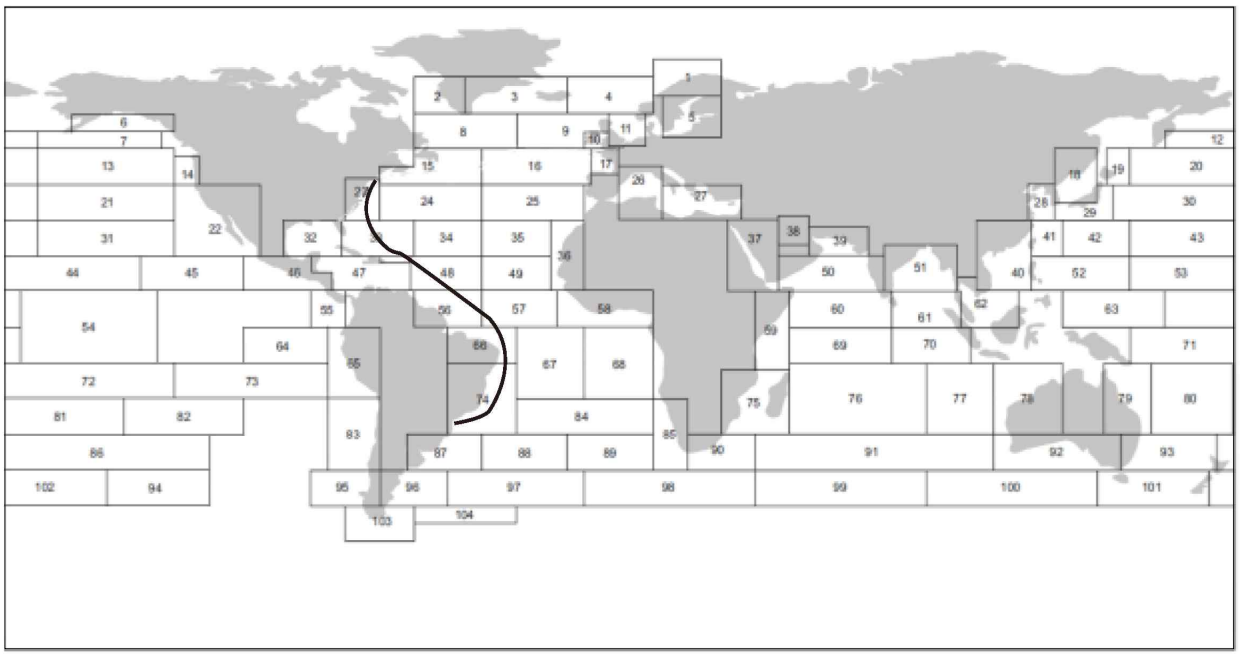
9. Europe (Rotterdam) - Africa



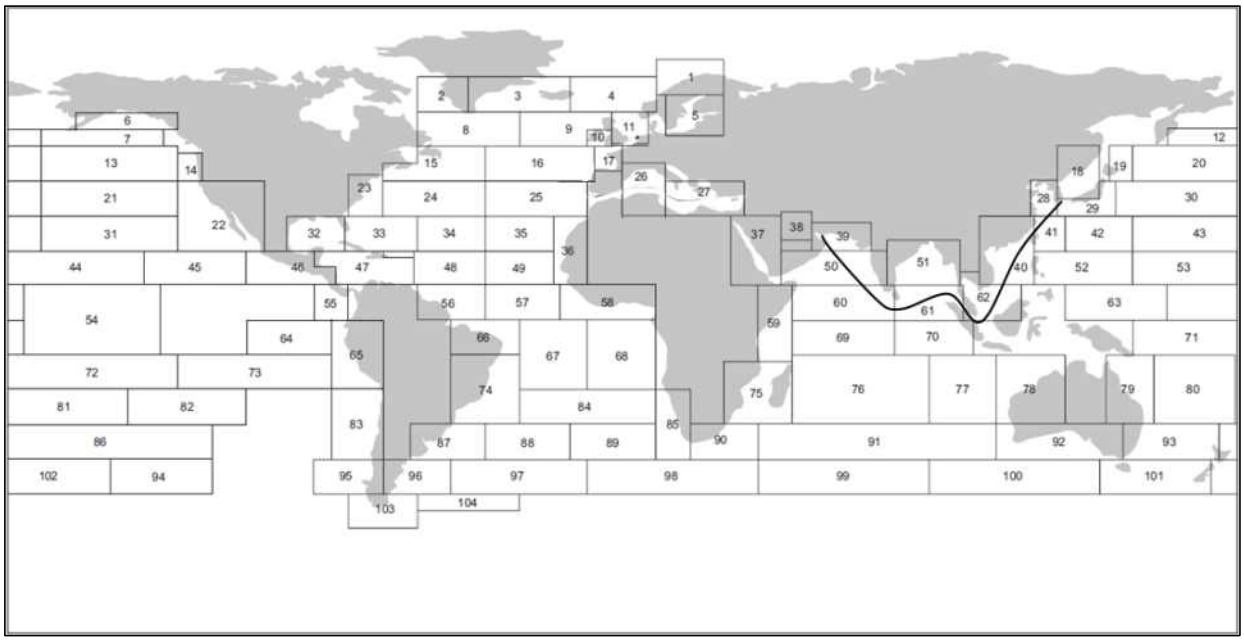
10. Europe (Rotterdam) - South America (Brazil)



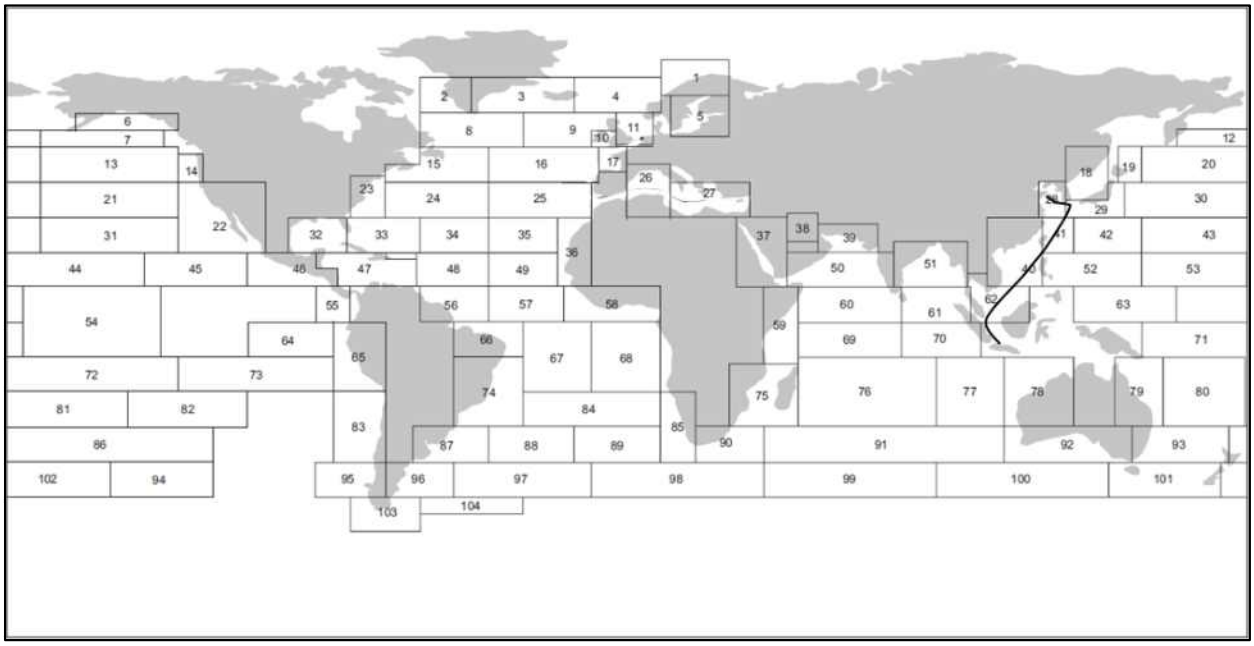
11. US (NYC) – South America (Brazil)



12. Asia – Middle East Asia



13. Intra Asia



Appendix 3 Sample Calculation based on equations

3.1 For unlashed condition as shown in left part of **Fig A3.1**, the sample stack has 7 tiers with 2.438m of breadth(a_i) and 2.510m of total height(h_i) for each container. For simple calculation, following assumptions for each container are applied in this example.

. 6 kN of weight

. 1.0 $\mathrm{m/sec^2}$ of horizontal acceleration

. -2.0 $\mathrm{m/sec^2}$ of vertical acceleration.

. omitting of wind force and shear force

. 3.7 $\mathrm{kN/mm^2}$ of spring constant for each container's door side

In case of lashed condition as shown in right part of **Fig A3.1**, double lashed condition and lashing bridge with 2-tier height are applied.

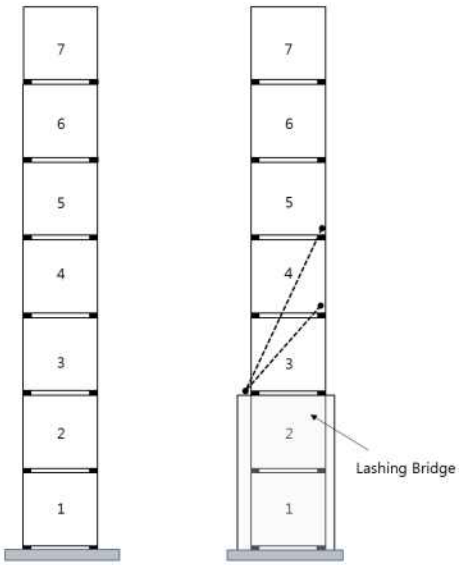


Fig A3.1 Unlashed and lashed condition for sample calculation

3.2 Racking force of each container for unlashed condition in accordance with **8.**(3) is showed in **Table A 3.1**

Table A3.1 Racking force calculation for unlashed condition

No. of tier	W_i	a_y	a_z	a_i	h_i	H_i	P_i	F_i	$Ru_i = \sum_{k=1}^{i} F_i$
7	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	1.0	1.0
6	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	4.0
5	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	7.0
4	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	10.0
3	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	13.0
2	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	16.0
1	6.0	1.0	-2.0	2.438	2.510	3.0	-3.0	3.0	19.0

3.3 Moments due to racking forces are transmitted to the compression and lifting force according to following equation;

$$\sum_{j=i}^{n}\left(F_j\sum_{k=i}^{j}h_k\right)$$

If i-th container is 5, the moment is as below and detail result for other containers is showed in **Table A3.2**.

$$\sum_{j=5}^{n}\left(F_j\sum_{k=5}^{j}h_k\right)$$

$$= F_5(h_5) + F_6(h_5+h_6) + F_7(h_5+h_6+h_7)$$

$$= 3.(2.51) + 3.(2.51+2.51) + 1.(2.51 + 2.51. + 2.51)$$

$$= 7.53 + 15.060 + 7.53$$

$$= 30.120\,(\mathrm{kN}-\mathrm{m})$$

Table A3.2 Moments due to racking forces for unlashed condition

No. of tier	$F_j\sum_{k=1}^{j}h_k$	$F_j\sum_{k=2}^{j}h_k$	$F_j\sum_{k=3}^{j}h_k$	$F_j\sum_{k=4}^{j}h_k$	$F_j\sum_{k=5}^{j}h_k$	$F_j\sum_{k=6}^{j}h_k$	$F_j\sum_{k=7}^{j}h_k$
7	17.570	15.060	12.550	10.040	7.530	5.020	2.510
6	45.180	37.650	30.120	22.590	15.060	7.530	
5	37.650	30.120	22.590	15.060	7.530		
4	30.120	22.590	15.060	7.530			
3	22.590	15.060	7.530				
2	15.060	7.530					
1	7.530						
$\sum_{j=i}^{n}\left(F_j\sum_{k=i}^{j}h_k\right)$	175.700	128.010	87.850	55.220	30.120	12.550	2.510

3.4 According to **8.**(3), compression and lifting force are shown as below when i-th container is 5.

$$Cu_5 = \sum_{j=5}^{n}P_j - \frac{1}{a_5}\sum_{j=5}^{n}\left(F_j\sum_{k=5}^{j}h_k\right)$$

$$= (P_5+P_6+P_7) - \frac{1}{a_5}(30.120)$$

$$= (-3.0-3.0-3.0) - \frac{1}{2.438}(30.120) = -9.0 - 12.354 = -21.354\,(\mathrm{kN})$$

$$Lu_5 = \sum_{j=5}^{n}P_j + \frac{1}{a_5}\sum_{j=5}^{n}\left(F_j\sum_{k=5}^{j}h_k\right)$$

$$= (P_5+P_6+P_7) + \frac{1}{a_5}(30.120) = -9.0 + 12.354 = 3.354\,(\mathrm{kN})$$

Rest of results are shown in **Table A3.3**.

Table A3.3 Compression and lifting forces for unlashed condition

No. of tier	$\sum_{j=i}^{n}\left(F_j\sum_{k=i}^{j}h_k\right)$	$\frac{1}{a_i}\sum_{j=i}^{n}\left(F_j\sum_{k=i}^{j}h_k\right)$	$\sum_{k=i}^{n}P_k$	Cu_i	Lu_i
7	2.510	1.030	-3.000	-4.030	-1.970
6	12.550	5.148	-6.000	-11.148	-0.852
5	30.120	12.354	-9.000	-21.354	3.354
4	53.220	22.650	-12.000	-34.650	10.650
3	87.850	36.034	-15.000	-51.034	21.034
2	128.010	52.506	-18.000	-70.506	34.506
1	175.770	72.067	-21.000	-93.067	51.067

3.5 In case of double lashed condition with lashing bridge as shown in **Fig A3.1**, the assumptions of lashing rods for simple calculation are as below;

. location of lower connection of lashing rods is left bottom corner of 3-rd container

. location of upper connection of short lashing is right bottom coner of 4-th container

. location of upper connection of long lashing is right bottom coner of 5-th container

. 1 mm^2 of sectional area for each lashing rod

. properties are shown in **Table A3.4**

Table A3.4 Properties of lashing rods

	No. of tier	E_i	ℓ_i	θ_i(rad)	A_i	$K_i = \frac{E_i A_i \cos^2\theta_i}{\ell_i}$
Long lashing	4	175.0	5.581	1.119	1	5.98
Short lashing	3	140.0	3.499	0.800	1	19.42

According to equations in **Fig 9**, if i is 3 and $i+1$ is 4, the horizontal and vertical support forces due to lashing rod are follows.

$$T_3\cos\theta_3 = \frac{K_3K_4\left[\left(\sum_{k=1}^{3}Ru_k\right)-3Ru_4\right]+K_3K_c\sum_{k=1}^{3}Ru_k}{3K_3(K_4+K_c)+K_c[(3+1)K_4+K_c]}$$

$$= \frac{19.42\times5.98\times[(13+16+19)-3\times10.0]+19.42\times3.7\times(13+16+19)}{3\times19.42(5.98+3.7)+3.7(4\times5.98+3.7)}$$

$$= 8.314\,(\mathrm{kN})$$

$$T_4\cos\theta_4 = \frac{K_4\left(K_c\sum_{k=1}^{4}Ru_k\right)+3K_3K_4Ru_4}{3K_3(K_4+K_c)+K_c[(3+1)K_4+K_c]}$$

$$= \frac{5.98[3.7(10+13+16+19)+3\times19.42\times5.98\times10}{3\times19.42(5.98+3.7)+3.7(4\times5.98+3.7)}$$

$$= 7.158\,(\mathrm{kN})$$

$$T_3\sin\theta_3 = (T_3\cos\theta_3)\tan(\theta_3) = 8.314\times\tan(\theta_3) = 8.599\,(\mathrm{kN})$$

$$T_4\sin\theta_4 = (T_4\cos\theta_4)\tan(\theta_4) = 7.518\times\tan(\theta_3) = 14.739\,(\mathrm{kN})$$

3.6 Racking force of each container for double lashed condition in accordance with **8.**(5) is showed in **Table A3.5**

Table A3.5 Racking force calculation for lashed condition

No. of Tier	$T_i\cos\theta_i$	$T_i\sin\theta_i$	$Ft_i = F_i - T_i\cos\theta_i$	$Pt_i = P_i - T_i\sin\theta_i$	Rt_i
7			1.000	-3.000	1.000
6			3.000	-3.000	4.000
5			3.000	-3.000	7.000
4	7.158	14.739	-4.158	-17.739	2.842
3	8.314	8.559	-5.314	-11.559	-2.472
2			3.000	-3.000	0.528
1			3.000	-3.000	3.528

3.7 Moments due to racking forces for double lashed condition are obtained according to similar approach described in **A3.3.** The results are shown in **Table A3.6**.

Table A3.6 Moments due to racking forces for lashed condition

No. of Tier	$Ft_j\sum_{k=1}^{j}h_k$	$Ft_j\sum_{k=2}^{j}h_k$	$Ft_j\sum_{k=3}^{j}h_k$	$Ft_j\sum_{k=4}^{j}h_k$	$Ft_j\sum_{k=5}^{j}h_k$	$Ft_j\sum_{k=6}^{j}h_k$	$Ft_j\sum_{k=7}^{j}h_k$
7	17.570	15.060	12.550	10.040	7.530	5.020	2.510
6	45.180	37.650	30.120	22.590	15.060	7.530	
5	37.650	30.120	22.590	15.060	7.530		
4	-41.748	-31.311	-20.874	-10.437			
3	-40.013	-26.676	-13.338				
2	15.060	7.530					
1	7.530						
$\sum_{j=i}^{n}\left(Ft_j\sum_{k=i}^{j}h_k\right)$	41.228	32.373	31.048	37.253	30.120	12.550	2.510

3.8 According to **8.**(5), compression and lifting force for internal double lashed condition are shown as below when i-th container is 3.

$$Ct_3 = \sum_{j=3}^{n} Pt_j - \frac{1}{a_3}\sum_{j=3}^{n}\left(Ft_j \sum_{k=3}^{j} h_k\right)$$

$$= (-3-3-3-17.739-11.559) - \frac{1}{2.438}31.048 = -51.034\,(\mathrm{kN})$$

$$Lt_3 = \sum_{j=3}^{n} P_j + \frac{1}{a_3}\sum_{j=3}^{n}\left(Ft_j \sum_{k=3}^{j} h_k\right)$$

$$= (-3-3-3-3-3) + \frac{1}{2.438}31.048 = -2.265\,(\mathrm{kN})$$

Rest of results are shown in **Table A3.7**.

Table A3.7 Compression and lifting forces for internal lashed condition

No. of tier	$\sum_{j=i}^{n}\left(F_j \sum_{k=i}^{j} h_k\right)$	$\frac{1}{a_i}\sum_{j=i}^{n}\left(F_j \sum_{k=i}^{j} h_k\right)$	$\sum_{k=i}^{n} Pt_k$	$\sum_{k=i}^{n} P_k$	Ct_i	Lt_i
7	2.510	1.030	-3.000	-3.000	-4.030	-1.970
6	12.550	5.148	-6.000	-6.000	-11.148	-0.852
5	30.120	12.354	-9.000	-9.000	-21.354	3.354
4	37.253	15.280	-16.739	-12.000	-42.019	3.280
3	31.048	12.735	-38.299	-15.000	-51.034	-2.265
2	32.373	13.279	-41.299	-18.000	-54.577	-4.721
1	41.228	16.911	-44.299	-21.000	-61.209	-4.089

Annex 7-3 Guidance for Car Ferries

1. Application

(1) This Annex is applied to the car ferries which are subject to Korean Ship Safety Act and Notification having a restricted to domestic service. And this annex with respect to may apply to car ferries constructed with material other than steel. However, car ferries constructed in compliance with the related International Conventions are regarded as complying with this Annex. Where the ships are not subject to Korean Ship Safety Act, provided that the ships have undergone survey according to relevant governmental regulation and allowed to operate within costal area, the application of this Annex may to be dispensed with.

(2) This Annex is not applied to Pure Car Carries and General Cargo Ship which is designed and constructed for the carriage of vehicles in the cargo holds.

(3) For the requirements not mentioned in this Annex, they are to be comply with related requirements on Rules and Guidance.

(4) In addition to the requirements in (3), for the requirements not mentioned in this Annex are to be comply with related requirements on Korean Ship Safety Act.

2. Definition

(1) "Car ferry" means that a ship is provided with a vehicle deck loading and carrying vehicles.

(2) "Passenger ferry" means that the car ferry is carrying passengers not less than 13 persons in addition to vehicles.

(3) "Vehicle area" means the cargo area for transporting automobiles with fuel tanks for driving.*(2018)*

(4) "Vehicle deck" means the deck providing passageway of vehicles or vehicle loading deck providing in vehicle area.

(5) "Open space" means an area with an open area of 10% or more of the side shell plating, deck plating, or permanent openings above the total area of the side of the space and with both open ends or one open end. This area should be provided with adequate natural ventilation over the entire length.*(2018)*

(6) "Closed space" means vehicle area other than open space mentioned (5) and exposed deck. *(2018)*

(7) "Bow door, etc" means bow door, stern door, inner door, side door and ramp(excluding the ramp which is installed on board for the moving of cargo between decks).

3. Submission of plans and documentations

For the ferries intended to register to this Society, the following plans and documentations are to be submitted to the Society in addition to plans and documentations described in **Pt 3, Ch 1, 301., 302., Pt 5, Ch 1, Sec 3, Pt 6, Ch 1, 102.** and **Pt 8, Ch 1, 102.** of the Rules prior to keel laid.

(A) Data which is able to be conformed the foreordinated route of ferry, (for examples; conviction certificate of Owner or provisional Approvals for operation issued by the Authority).

(B) Vehicle and cargo loading plan

(C) Construction profile of bow door, etc., details, opening and closing equipment(including driving systems), remotely controlled systems and description.

(D) Construction profile of ramp other than bow door, etc., details, opening and closing equipment(including driving systems) and description.

4. Arrangement of hull

(1) Forecastle

Forecastle is to be provided to the car ferries engaged in coastal service and it's over (For the ship having a port of call in middle of operation, operating time as regarded as between port of call.) However, when the operating time is not greater than one hour with their maximum speed in coastal area over fresh water area, forecastle may not be provided.

(2) Fore peak bulkhead

For the ship which is able to take a both ahead and stern direction with proceeding direction, bulkheads having equivalent ability to fore peak bulkhead described in **Pt 3, Ch 14** are to be

provided to both fore and after peak.

5. Vehicle deck

(1) Strength
Strength of vehicle deck is to be in accordance with **Ch 7, Sec 3.**

(2) Exposed vehicle deck
(A) Bulwarks complying with **Pt 4, Ch 4, Sec 1** of the Rules are to be provided to exposed vehicle deck. At the fore end part, height of bulwarks is to be appropriately increased.
(B) Freeing ports complying with **Pt 4, Ch 4, Sec 2.** of the Rules are to be provided in bulwark and overboard discharges complying with **Pt 5, Ch 6, Sec 3** of the Rules are to be provided on deck.

(3) Closed vehicle deck
Discharging equipments complying with **Pt 5, Ch 6, Sec 3** of the Rules are to be provided and they are not to be directly crossed through the engine room.

6. Vehicle area

(1) Construction
(A) Vehicle area for the car ferries engaged in coastal service and it's over is to be constructed with weather tightness. However, for the car ferries which are navigate to be less than one hour with their maximum speed in coastal area over fresh water area, (For the ship having a port of call in middle of operation, operating time as regarded as between port of call, operating time as regarded as between port of call.) or for the car ferries having vehicle deck, which is located in upper deck upward to freeboard deck, is located in backward to fore peak bulkhead and the vertical height between load line and considered vehicle area is of 2 times or greater than that of standard superstructure specified in the "Ship's Load Line" of Korean Ship Safety Act, they may not be constructed with weather tightness.
(B) In closed vehicle area, for the fore castle having a length over than $0.25L_f$, the watertight bulkhead which is to extend up to the forecastle deck or inside door constructed with weather tightness at the position of collision bulkhead is to be provided.

(2) Doors provided in closed vehicle area
(A) All doors passing to vehicle area may be automatically closed type and those may be opened from inside and outside. These doors are to be complied with the relevant requirements of weather tightness and fire protection.
(B) The height of doorsill for access door and coaming of access hatch which may be access through the under of freeboard deck from vehicle area is to be not less than 230 mm and access door and coaming of access hatch which may be access through machinery room is to be not less than 380 mm.
(C) Above (A) and (B) are not to be applied to the ferries engaging in smooth sea area.

(3) The heights of doorsill for access door and coaming of access hatch which may be access through the under of freeboard deck from vehicle area and access door and coaming of access hatch which may be access through machinery room are to comply with **Guidance Pt 3, Ch 1, Table 3.1.2.** These heights are to be complied with the relevant requirements of weather tightness and fire protection.

(4) Passenger's room
(A) Passenger's room is not to be provided under the vehicle area.
(B) When the passenger's room is provided on the same deck, they are to be divided with steel bulkhead or heat protection bulkhead complying with the requirements of "Regulations for ship's fire protection" of Korean Ship Safety Act.

(5) Evacuation equipment
For the car ferries, evacuation equipment is to comply with **Ch 2** of "Regulations for Ship's Equipment" in Korean Ship Safety Act.

(6) Ventilation
(A) For the closed vehicle area, sufficient ventilation system is to be provided and it is to be exhausting type except when the prevention of inflow the gases from vehicle area is provided to machinery space, accommodation and service space, it is to be complied with the followings.
(a) It is to be independent from the other ventilation systems.
(b) It is able to ventilate the air of 10 times amount of closed vehicle area capacity (for the

cargo ferries, 6 times when deemed appropriate by the Society).
(c) It is to be controlled in external space
(d) In addition to (a) to (c), it is also complied with **Pt 8, Ch 13, 201.** 2 (3), 3, **202** to **204.**

(B) The machinery and service spaces located under the vehicle deck are to be ventilated sufficiently and this ventilation system is to be of suction type. (suction of fresh air from atmosphere and supply to the spaces)

(7) Either one of the following equipment is to be provided to the car ferries having a closed space.
(A) CCTV which is capable of monitoring the whole vehicle area on the navigation bridge
(B) Light indicator and audible alarm which is capable of confirming the state of opening/closing of vehicle area entrance door on the navigation bridge

(8) Indication in vehicle area
(A) In the vehicle area, the passageway for the using of access door, stairway, life saving appliances or fire extinguishing appliances is to be provided. This passageway is to be discriminated boundary line with easily visible color.
(B) For the ferries, when the lamp or inside door is not provided in location of fore peak bulkhead the warning mark "Vehicles may not be loaded forward the fore peak bulkhead" is to be provided.
(C) Vehicle area is to be marked clearly and vehicle load plan including following items is to be posted in the location where they are easily recognized.
(a) Maximum load of ship
(b) Maximum number of vehicles
(c) Notice items in loading vehicle
(D) "Notice items in loading vehicle" in (C) (c) is as follows and is to be included in vehicle and cargo load plan.
(a) Axle loads are not to exceed 00 ton(axle load is reviewed based on the maximum load 00 ton truck.
(b) The total weight of vehicles(including loaded on the vehicle) which is loaded on ship are not to exceed 00 ton(the total weight of vehicles is reviewed based on the number(00 vehicles) of maximum load 00 ton truck.)
(c) When the loaded vehicles are increased according to the loading of similar vehicles, proper type and number of movable securing devices which has sufficient strength is to be provided additionally.
(d) When similar vehicles are loaded, the loading and arrangement of the vehicles are to be properly to ensure the stability.

7. Vehicle load method and securing device

(1) Vehicle load method
(A) Vehicles are to be loaded toward the direction of bow and stern. However, when the sufficient additional treatments for transverse sliding such as wedges etc. are provided, it may not be needed.
(B) Vehicles are not to be loaded forward the fore peak bulkhead.
(C) The space between loaded vehicles is not to be less than 600 mm.
(D) In the vehicle area, boundary line with easily visible color or the protection is to be provided for the access prohibition within 1 m near the access door, stairway and fire extinguishing arrangements.
(E) Vehicles are to be arranged to allow sufficient space for the passageway leading to assembly stations and embarkation stations etc. in an emergency.

(2) Vehicle securing method
(A) Vehicles are to be secured to the ship by fixed securing devices(e.g.: D-ring, Clover socket and Deck eye plate etc.) and movable securing devices(e.g.: Web lashing, Turn buckle and Chain etc.) which are comply with the requirements in (4).
(B) Securing devices(fixed and movable securing devices) fixing vehicles and general cargos are to be approved by the Society. However, when securing devices are manufactured by approved manufacturer which is approved by the Society according to international standard such as ISO etc., the approval may be replaced by the manufacturer's certificate.
(C) Sufficient number of fixed securing devices are to be provided to consider the loading of vehicles which are not marked in vehicle and cargo loading plan.
(D) movable securing devices for the car ferries(1,000 tons gross tonnage and above) engaged in coastal service and it's over are to be provided to more than 1.2 times of approved amount.

(E) The securing of vehicle is to be loaded in accordance with vehicle and cargo loading plan. Before and during the voyage, it is to be checked by crews.

(F) The securing of vehicle is to be secured by more than 4 wheels or 2 parts of front and rear of vehicle using provided securing devices in vehicle and more than 4 fixed securing devices.

(G) For the car ferries which is only engaged in smooth water and having not more than 30 min. of navigating time, the car ferries which has less than 1 hour of navigating time in smooth water and coastal area service and loaded with cars, less than 12-seater's passenger vans and 1.5 ton truck (For the ship having a port of call in middle of operation, a port of call as regarded as departure port and arrival port), if they have a sufficient treatments for non-slip as keys etc. with smooth sea condition(wave height is to be less than 1.5 m and wind speed is to be less than 7 m/sec), vehicles may not be secured.

(3) Vehicle cargo loading

(A) The capacity of cargo being loaded on the vehicle is to comply with following requirements.

(a) The length of loaded cargo is to be less than the length of vehicle plus one tenth of the length of vehicle

(b) The width of loaded cargo is to be less than the range which can be checked by rear view mirror.

(c) The height of loaded cargo is to be less than 4 m from the ground. Where the truck such as a van etc. having cargo space with roof cover, the height is from the ground to the top of the cover.

(B) Cargo being loaded on the vehicle is to be secured to ensure the load by the movements of ship which is described in the (4).

(4) Strength of securing device

(A) The definitions of terms that are used to assess the strength of the securing devices are as follows.

W = total weight of vehicle(load + vehicle weight) (ton)

x, y, z = longitudinal, transverse and vertical distance from the center of rolling and pitching to the center of under consideration vehicle, respectively

ϕ, ψ = rolling and pitching angle of ship as specified in **Table 1** respectively (deg) (see **Fig 1)**

T_r, T_p = rolling and pitching cycle of ship as specified in **Table 1** respectively (sec)

V = vertical force to deck during rolling and pitching of ship (ton) (see **Fig 1)**

H_r = force acting to transverse direction which is parallel to deck during rolling of ship (ton) (see **Fig 1)**

H_p = force acting to longitudinal direction which is parallel to deck during pitching of ship (ton) (see **Fig 1)**

M_r = overturing moments during rolling of ship (ton-m) (see **Fig 2)**

SF_r, SF_p = forces acting on vehicle which is parallel to longitudinal and transverse deck respectively (ton)

b_m = full width of vehicle (m) (see **Fig 2)**

b_t = spacing of wheels (m) (see **Fig 2)**

h_m = height from deck to the center of gravity of the vehicle (m) (see **Fig 2)**

L_r, L_p = sum of the transverse and longitudinal horizontal component which movable securing devices can withstand (ton)

M_l = sum of the force to resist for vehicle overturning moment by movable securing devices (ton)

n = number of movable securing devices used for one vehicle

α, β = transverse and longitudinal angle between movable securing devices and deck respectively (deg) (see **Fig 2)**

h = height from deck to the point of vehicle securing (m) (see **Fig 2)**

T = safety working load of movable securing devices which is divided breaking load with

safety factor of **Table 1** (ton)

μ = friction coefficients between vehicle and deck, as shown below

tire(rubber) / non-slipped paint: 0.7 [1)]

tire(rubber) / steel deck: 0.3

steel / steel deck: 0.1(when dry)

steel / steel deck: 0.0(when wet)

timber / steel deck: 0.3

1): The coefficient of friction of paints approved in accordance with the Guidance for Approval of Manufacturing Process and Type Approval or coefficient of friction of test report acceptable to the Society may be used. *(2018)*

(B) The loads acting on the securing device is to be determined in consideration of the movements of ship which is described in the **Table 1.**

(C) Each component of the loads caused by motions of the ship is shown in **Fig 1** and **Table 2**.

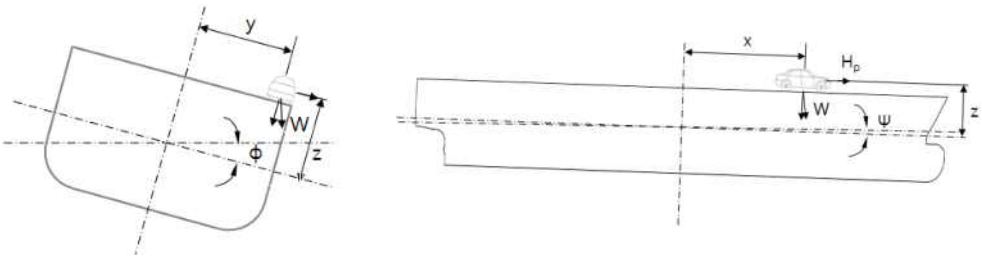


Fig 1 Motions of the ship

Table 1 Ship motion

Item / Classification	Rolling		Pitching		Safety factor
	degree	cycle 3)	degree	cycle	
Ferries engaging over coastal area	25°	cycle of ship	5°	5 sec	4 over
Ferries that voyaged time is less one hour or smooth water area	10°				

(Note)

1. KG' is the value obtained from the following formula.

$$KG' = 0.5(KG + KB)$$

KG = the vertical position of the centric of the ship

KB = the vertical position of the buoyancy centric of the ship

2. The centric of pitching is to be longitudinal position of the centric of the ship.
3. The rolling cycle of the ship may be taken from the following formula.

$$T_r = \frac{0.7B}{\sqrt{GM}}$$

Table 2 Load components

Type		Load components (ton)		
		Vertical force	Horizontal force	
			transverse	longitudinal
Static load	Rolling	$W\cos\phi$	$W\sin\phi$	-
	Pitching	$W\cos\psi$	-	$W\sin\psi$
	Combination	$W\cos(0.71\phi)\cos(0.71\psi)$	$W\sin(0.71\phi)$	$W\sin(0.71\psi)$
Dynamic load	Rolling	$0.07024\,W\frac{\phi}{T_r^2}y$	$0.070247\,W\frac{\phi}{T_r^2}z$	-
	Pitching	$0.07024\,W\frac{\psi}{T_p^2}x$	-	$0.07024\,W\frac{\psi}{T_p^2}z$

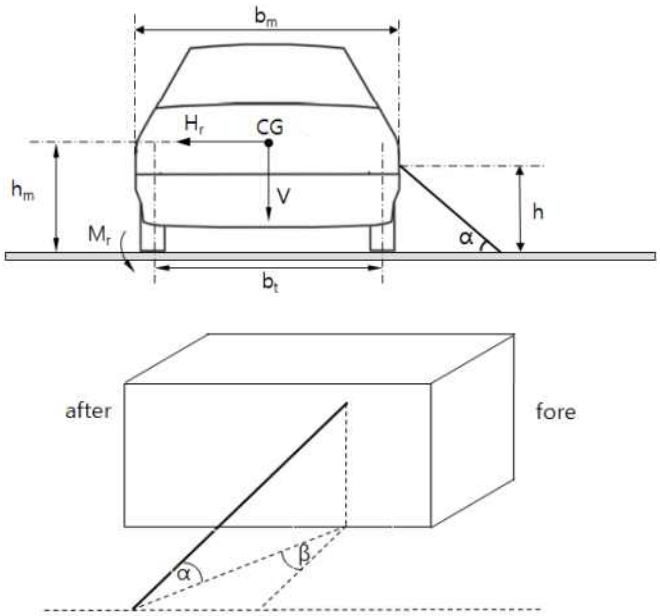


Fig 2 Various dimensions during vehicle securing

(D) The forces caused by motions of the ship are as follows.
(a) Vertical force: the smallest among V_1, V_2 and V_3

$$V_1 = W\left[\cos(0.71\phi)\cos(0.71\psi) - 0.07024\frac{\phi}{T_r^2}y - 0.07024\frac{\psi}{T_p^2}x\right]$$

$$V_2 = W\left[\cos\phi - 0.07024\frac{\phi}{T_r^2}y\right]$$

$$V_3 = W\left[\cos\psi - 0.07024\frac{\psi}{T_p^2}x\right]$$

(b) Transverse horizontal force:

$$H_r = W\left[\sin\phi + \frac{0.07024\phi}{T_r^2}z\right]$$

(c) Longitudinal horizontal force:

$$H_p = W\left[\sin\psi + \frac{0.07024\psi}{T_p^2}z\right]$$

(E) The loads to be considered as acting on the vehicle are to be determined according to following formula.
(a) Transverse horizontal force

$$SF_r = H_r - \mu V$$

(b) Longitudinal horizontal force

$$SF_p = H_p - \mu V$$

(c) Rolling overturing moments

$$M_r = H_r \times h_m - 0.5\,V \times b_m$$

(F) The forces caused by motions of the ship are as follows.
(a) Transverse horizontal component:

$$L_r = \sum_{i=1}^{n/2} T_i \bullet (\cos\alpha_i \bullet \cos\beta_i + \mu\sin\alpha_i)$$

(b) Longitudinal horizontal component:

$$L_p = \sum_{i=1}^{n/2} T_i \bullet (\cos\alpha_i \bullet \sin\beta_i + \mu\sin\alpha_i)$$

(c) overturing moments horizontal component:

$$M_l = \sum_{i=1}^{n/2} T_i \bullet (0.5(b_m + b_t)\sin\alpha_i + h \bullet \cos\alpha_i\cos\beta_i)$$

(G) Movable securing devices are to be complied with following formula.
(a) Transverse horizontal component : $SF_r \leq L_r$
(b) Longitudinal horizontal component : $SF_p \leq L_p$
(c) overturing moments horizontal component : $M_r \leq M_l$

(5) Drawing guidance for vehicle and cargo loading plan
(A) The arrangement and loading method of vehicles intended to load among the vehicles as specified in "Enforcement Regulations of the Automobile Management Act Appendix Table 1" is to be indicated in the loading plan. In this case, where the total weight of the vehicle is within the range of the total weight of the approved vehicle and fixation method and securing strength is suitable, other vehicles, construction machinery as specified in "Presidential Decree for the Construction Machinery Management Act Appendix Table 1" and agricultural machinery as specified in "Enforcement Regulations of the Agricultural Mechanization Promotion Act Appendix Table 1" etc. are to be loaded in accordance with the loading plan.
(B) Notwithstanding the (A) above, where the vehicle type intended to load is decided by the owner of car ferry especially, the vehicle loading plan reflected the arrangement and loading method of the vehicle is to be approved.
(C) Where intended to load the vehicle other than (A) above, the vehicle loading plan reflected the arrangement and loading method of the vehicle is to be approved additionally.

(D) Vehicle and cargo loading plan is to be included following items.
(a) arrangement and detail of fixed securing devices(types, material, breaking strength etc.)
(b) detail of movable securing devices(material, breaking strength, instructions etc.)
(c) arrangement and securing details for the vehicles intended to load(position of securing point of vehicle and ship, type of movable securing devices)
(d) specification of the vehicles intended to load(length and width of vehicle, vehicle weight including cargo weight)
(e) fire-extinguishing appliances, drainage facilities and passageway
(f) notice in **Par 6** (8) (D)
(g) when cargoes other than vehicles are loaded, the description of loading and securing method

(6) Cargo loading other than vehicles
(A) In the vehicle area, unless it is approved by the Society, no cargoes other than vehicles may be loaded. For the cargoes loading other than vehicles, the documents for the closure and loading arrangements by the kinds of cargoes are to be submitted and approved by this Society.

(B) For freight container in one tier, the container is to be secured at their lower 4 corners by fixed securing devices(socket, D-ring, sliding base, lashing plate etc.) which is secured to the ship. For freight container in more than two tiers, the container is to be secured at their lower 4 corners to the upper 4 corners of below container by movable securing devices(twist lock, stacker etc.) or the container is to be secured directly to ship by lashing rod or turnbuckle. These fixed and movable securing devices are to comply with the requirement in **Guidance** Annex 7-2.
(C) General cargoes(excluding passenger's personal belongings) except cargoes approved in vehicle and cargo loading plan it's arrangement • loading • securing method is to be loaded in storage facilities to made available for securing and is to be secured to comply with the requirement in (4).

8. Bow door, etc

(1) General
(A) Bow and stern door, inner door, side door and ramp of all ferries are to be provided in the upper freeboard deck.
(B) For the ferries engaged in coastal area and over, bow and stern door and side door is to be weather tightness. However, when the inner door or ramp with weather tightness is provided inside of bow door, closure of bow door may be properly considered.
(C) For the ferries having bow door, the structure and arrangement of lamp and inner door is to be in accordance with **Pt 3, Ch 14, 201** and **205** of the Rules.
(D) The strength of bow and stern door, inner door, side door and ramp are to be comply with **Pt 4, Ch 3.** and have a strength larger than that of near members. Near parts of side door is to be properly compensated.

(2) Strength of lamp *(2018)*
The strength of ramp is to be complied with the followings. When the stern and inner door are used for ramp, the followings are to be satisfied.
(A) The thickness of deck to ramp t is to be in accordance with the requirements in **Ch 7, 301. 1.**
(B) The section modulus Z of tripping brackets is to be in accordance with the requirements in **Ch 7, 301. 2.**
(C) The dimensions of longitudinal and transverse girders of the lamp deck can be calculated by assuming that the girder is a simple support beam or continuous beam. In this case, the load should be the designed maximum vehicle load and the allowable deflection should be less than 1/800 of the span. Alternatively the dimensions may be determined by direct strength calculation method. In this case, the load is not less than the value calculated by using 1.3 times of designed maximum vehicle load(ton) and permissible stress 177/K $\mathrm{N/mm^2}$.
(D) The strength of ramp which is considered as one of shell for navigating is not less than that of side shell or upper structure.

(3) Remotely controlled opening/closing systems
(A) Where the remotely controlled opening/closing systems devices, the followings are to be complied with.

(a) Control panel is so to be placed that controller may easily observe excepting that the controller may observe opening/closing of the door at the position where the control panel is placed.
(b) The indicating system for opening/closing systems of door is to be provided at the navigation bridge.
(c) Locking device which is able to be stopped at each step is to be provided.

(B) Where the remote control panel is provided at the bow side of exposed deck, the door is to be closed when the lever is pulled to the direction of stern side. The hinged steel cover is to be provided for preventing damage due to the waves and so on.

(4) Closing devices *(2018)*

(A) For the car ferries, opening / closing systems and securing device (hereinafter as referred to closing devices) are to be provided for bow door's perfectly securing. These are able to prevent for easy opening of bow door due to vibration and ship's movement.

(B) In the above (A), closing device is provided with secondary means. If one device is damaged, closing of door is to be maintained by the other one.

(C) Closing devices of bow door are to be easily confirmed the condition of closing at the bridge or control station. They does not cause any inconvenience for passing of passengers during navigation.

(D) Design load and permissible stress of securing devices are to be in accordance with **Pt 4, Ch 3.**

(5) Notice

The approved operation method and any attention for vehicle door are to be noticed near to the door or control panel.

9. Air pipe and sounding pipe

(1) Fuel tanks

(A) End of opening of air pipe in all fuel tanks is to be provided on safe area of exposed deck which has not a capability of overflow or gas emitting and it is to be opened in closed vehicle area.

(B) The upper parts of sounding pipe of fuel tanks are to be provided on safe area of exposed deck. However, if it is not available, it may be provided at the space from a distance with electrical equipments and other parts having high temperature. But in this case, cock or sluice valve which is a automatically closed type are to be provided.

(C) For the wire gauze to prevent the passage of flame provided on the end of openings or inside of air pipe, it is to be complied with **Pt 5, Ch 6, 201.** of the Rules.

10. Electric equipment

(1) The electric equipment in closed vehicle area are to be complied with **Ch 7, 402.** of the Rules.

(2) Emergency electric equipment

Requirements and application of emergency power of passenger ferries are in accordance with "Special Regulations for Car Ferries" in Korean Ship Safety Law.

(3) Installation and utilization of electricity supply cables to loaded vehicle

(A) A car ferry with enclosed vehicle loading space which carries live-fish transporting trucks must be installed with reel lead electricity supply cables which satisfies the below requirements, readily available to supply electricity for every each vehicle it carries.
(a) Must have a circuit breaker for overload
(b) Cables must be fire resistant

(B) A live-fish transporting truck on board the ferry must have it's engine turned off during the voyage and acquire the electricity necessary for oxygen supplier from the ferry.

11. Fire protection

The fire protection of car ferry is to comply with **Ch 6** of "Regulations for Ship's Fire Protection" in Korean Ship Safety Act.

12. Intact stability for car ferry

Intact stability of car ferries is to be complied with "stability criteria" in Korean Ship Safety Act.

13. Subdivision of passenger ferry and damage stability requirements

(1) Arrangement

(A) For the passenger ferries, compartments are to be so arranged that limit line is not to be submerged under water, even though one compartment is flooded.

(B) For the passenger ferries having not less than 45 m in length, in addition to (A), compartments are to be so arranged that limit line is not to be submerged under water, even though two compartment, one compartment by the side of the other compartment are flooded.

(C) For the passenger ferries having not less than 79 m in length, in addition to (A), compartments are to be so arranged that limit line is not to be submerged under water, even though any two compartments are flooded.

(2) Damage stability requirements

(A) Damage stability

(a) When the passenger ferries are damaged and any compartments described in (2) are flooded and are treated for equilibrium, the followings are to be complied with.

(i) When compartments are symmetrically flooded, GM is greater than 0.05 m.

(ii) When compartments are unsymmetrically flooded, angle of inclination is not greater than 7°, However, where any two adjacent compartments are flooded simultaneously, it may be 15°

(iii)Limit line is not be under water.

(b) For all passenger ferries has a necessary stability for the compliance with the above (a) for the all conditions.

(c) For the limit line is submerged under water during the flooding condition (a), ship has to be accomplished proper treatments deemed necessary by this Society.

(d) When the equilibrium is accomplished, maximum angle of inclination is to be approved by this Society.

(B) Damage stability calculation

(a) In damage stability calculation arrangement of flooding compartment, ship's ratio of dimension and property are to be considered in addition to (2) and the following (C), (D).

(b) For the ships having water-tightness deck, longitudinal bulkheads, inside shell, those are to be considered for ship's safety due to heeling when the compartments the parts surrounded by those are flooding.

(C) Flooding ratio of flooding compartment

Flooding ratio is 60 for the area of cargo, ore or stowage loaded, 90 for accommodation area, 85 for machinery space, 0 or 95 for the area where the liquid cargo is loaded whichever is worse. However, when the ships are damaged, more critical calculation is to be conducted for the area where the accommodation equipment or machinery equipment are not provided in due to located in near the water line and cargoes or packages are not stowed.

(D) Damage assumption

(a) The assumed extent of damage should be:

(i) Longitudinal extent : $l = 0.03L + 3 \quad (\mathrm{m})$ or 11 m, whichever is smaller.

(ii) Transverse extent : $0.2B\,(\mathrm{m})$ from the ship's side at right angles to the centerline at the level of the summer load line.

(iii) Vertical extent : top of the keel

(b) If any damage of smaller extent than the maximum damage specified in (a) would result in severer condition, such damage should be considered.

(E) Distance between transverse bulkhead

(a) When the distance between two neighbouring compartments, transverse bulkhead is less than the smaller of the l in the following formula or 11 m, (1) is applied by regarding that one of them is not provided.

$$l = 0.03L + 3 \quad (\mathrm{m})$$

(b) For the bended area is provided in transverse bulkhead, it is to be in accordance with Article 16(5) Par 2 of the "Standard for Construction and Appliances for Car Ferry" in Korean Ship Safety Law.

(F) Unsymmetrical flooding

(a) Unsymmetrical flooding is to be avoided as possible.

(b) The equipments for correction of large angle of inclination due to unsymmetrical flooding is to be automatical as possible, and it is approved by the Society.

(c) When the equipments specified in above (b) is cross flooding equipment, they are to be complied with the followings.

(i) When the control devices are provided, they may be controlled upper of bulkhead deck.

(ii) Equilibrium is to be completed in 15 min. and scantlings are to be complied with IMO Res.A266(Ⅷ) (including revision).

(G) Equipment for pipe damage

In this case, where any part of the bilge pipe is close to ship's side than a distance of one fifth of the width of the ship which is measured at right angles to the centerline at the level of the summer load line, it is to be provided a non-return valve to the pipe inside the compartment having the open end of the pipe.

Annex 7-4 Guidance for Calculating the Maximum Allowable and Minimum Required Mass of Cargo and Double Bottom Contents with Bulk Carriers

1. The maximum allowable cargo mass W_{MAX} and the minimum allowable cargo mass W_{MIN} for the each cargo hold which are to be described in Loading Manual as specified in **Pt. 3, Annex 3-1, 2.** (4) (A) of the Guidance are to be given by the following as a function of draft in way of the considered cargo hold.

(1) Maximum allowable cargo mass

(A) In the case where the scantlings of structural members of double bottom are determined by the formula prescribed in the requirements of the Rule

(a) The pressure which works on the ships bottom with mass of cargo or ballast water, $9.81\,h_x\gamma\,(\mathrm{kN/m^2})$ is to be not greater than the obtained with the following formula.

$$\max\{a_1 n_{f1}, a_2 n_{f2}, \cdots, a_n n_{fn}\} + 9.81(d_x - 0.026L'\alpha_R - h_{BST})$$

h_x : Stowage height to the cargo surface from the tank top at the center line (m). In any case, the height of the cargo surface cannot exceed that of the upper deck.

γ : Design specific gravity of cargoes for the cargo hold which is to be taken as $\frac{M_D}{V}$

M_D : Maximum cargo mass of the cargo hold considered (ton)

V : Volume of the cargo hold considered excluding the hatchway ($\mathrm{m^3}$)

a_i : Difference in pressure in loading condition No. i taken from a population with the total of n loading conditions, which works on the center line of the ships bottom with mass of cargo, ballast water and/or double bottom contents and by wave and still water corresponding to the draft ($\mathrm{kN/m^2}$), which is obtained from the following formula. The difference in pressure cannot, however, exceed the design pressure given to the local structural member of double bottom where the member is reinforced to enable ship to carry such heavy cargoes as steel coils.

$$\max\{|p_i - 9.81(d_i + 0.026L')|, |p_i - 9.81(d_i - 0.026L')|\}$$

p_i : Pressure in loading condition No. i, which works on the center line of the ship's bottom by the mass of cargo, ballast water and/or double bottom contents ($\mathrm{kN/m^2}$)

d_i : Draft in loading condition No. i, at mid-hold position of cargo hold length l_H (m)

l_H : Length of cargo hold (m) as defined in **Ch 3, 301. 4** of the Rules.

L' : Length of ship (m). Where exceeds 230 m, is to be taken as 230 m.

α_R : 1.0. However, on the water where there are small effects of ocean waves such as port area, that may be reduced to 0.5.

n_{fi} : 0.9 in loading condition No. i, in the case where the considered hold and either of the adjacent holds are loaded or empty simultaneously. In the other case, it is to be 1.0.

d_x : Draught at mid-hold position of cargo hold length l_H (m)

h_{BST} : Water heads of ballast water charged in the double bottom at the center line (m). In any case, it cannot exceed height of the double bottom.

(b) The maximum allowable cargo mass, W_{MAX} (ton), is to be not greater than the obtained with the following formula.

$$\gamma f(h_x)$$

$f(h_x)$: The function with shows the relationship between the stowage height $h_x(\mathrm{m})$ of cargo at the center line and the volume (m^3) of cargo loaded in the hold. In this case, the cargo may be uniformly supposed to be loaded under level surface.

(B) In the case where the scantlings of structural members of double bottom are determined by direct calculations

(a) The pressure which works on the ships bottom with mass of cargo or ballast water, $9.81h_x\gamma\,(\mathrm{kN/m^2})$, is not to be greater than the obtained with the following formula.

$$\max\{a_1, a_2, \cdots, a_n\}+10.0(d_x-0.25H_w\alpha_{DC}-h_{BST})$$

h_x, γ, d_x and h_{BST} : as specified in (A)

a_i : Difference in pressure in loading condition No. i taken from a population with the total of n loading conditions, which works on the center line of the ships bottom by mass of cargo, ballast water and/or double bottom contents and by wave and still water corresponding to the draft $(\mathrm{kN/m^2})$, which is obtained from the following formula. The difference in pressure cannot, however, exceed the design pressure given to the local structural member of double bottom where the member is reinforced to enable ship to carry such heavy cargoes as steel coils.

$$\max\{|p_i-10.0(d_i+0.25H_w)|\,,\,|p_i-10.0(d_i-0.25H_w)|\}$$

p_i : The pressure, in loading condition No. i, which works on the center line of the ships bottom by the mass of cargo, ballast water and/or double bottom contents $(\mathrm{kN/m^2})$. In calculating the pressure which arises by the mass of cargo, the density of cargo and the shape of cargo surface which were applied in direct calculations may be, however, taken into consideration.

d_i : Draught in loading condition No. I, at mid-hold position of cargo hold length $l_H(\mathrm{m})$

H_w : As obtained with the following formula.

$0.61L^{1/2}$ where $L \leq 150\mathrm{m}$
$1.41L^{1/3}$ where $150\mathrm{m} < L \leq 250\mathrm{m}$
$2.23L^{1/4}$ where $250\mathrm{m} < L \leq 300\mathrm{m}$
9.28 where $300\mathrm{m} < L$

α_{DC} : 1.0. On the waters where there are small effects of ocean waves such as the bay , it may be, however, reduced to one-third.

(b) The maximum allowable cargo mass, $W_{MAX}(\mathrm{ton})$, is to be not greater than the obtained with the following formula.

$$\gamma f(h_x)$$

$f(h_x)$: as specified in (A)

(2) Minimum allowable cargo mass

(A) In the case where the scantlings of structural members of double bottom are determined by the prescribed formula in the requirements of the Rule

(a) The pressure which works on the ships bottom with mass of cargo or ballast water, $9.81h_x\gamma\,(\mathrm{kN/m^2})$, is to be not less than the obtained with the following formula.

$$-\max\{a_1n_{f1}, a_2n_{f2}, \cdots, a_nn_{fn}\}+9.81(d_x+0.026L'\alpha_R-h_{BST})$$

h_x, γ, a_i, n_{fi}, d_x, L', α_R and h_{BST} : As specified in (1) (A)

(b) Minimum allowable cargo mass $W_{MIN}(\mathrm{ton})$ is to be not less than the obtained with the following formulas.

$$\gamma f(h_x)$$

$f(h_x)$: As specified in (1) (A)

(B) In the case where the scantlings of structural members of double bottom are determined by direct calculations

(a) The pressure which works on the ships bottom with mass of cargo or ballast water, $9.81h_x\gamma(\mathrm{kN/m^2})$, is to be not less than the obtained with the following formula.

$$\min\{a_1, a_2, \cdots, a_n\}+10.0(d_x+0.25H_w\alpha_{DC}-h_{BST})$$

h_x, γ, d_x, α_{DC}, h_{BST} and H_w : As specified in (1) (B)

a_i : Difference in pressure in loading condition No. i taken from a population with the total of loading conditions, which works on the center line of the ships bottom by mass of cargo, ballast water and/or double bottom contents and by wave and still water corresponding to the draft ($\mathrm{kN/m^2}$), which is obtained from the following formula taking a downward force as a positive value. The difference in pressure cannot, however, exceed the design pressure given to the local structural member of double bottom where the member is reinforced to enable ship to carry such heavy cargoes as steel coils.

$$\min\{(p_i-10.0(d_i+0.25H_w))\,,(p_i-10.0(d_i-0.25H_w))\}$$

p_i and d_i : As specified in (1) (B)

(b) Minimum allowable cargo mass $W_{MIN}(\mathrm{ton})$ is to be not less than the obtained with the following formula.

$$\gamma f(h_x)$$

$f(h_x)$: As specified in (1) (B)

2. The maximum allowable cargo mass W_{MAX} and the minimum allowable cargo mass W_{MIN} for the cargo hold and the adjacent cargo hold (hereinafter referred to as "two adjacent holds") which are to be described in Loading Manual as specified in **Pt 3, Appendix 3-1**, 2.(4)(D) of the Guidance are to be given by the following as a function of draft in way of these holds.

(1) Maximum allowable cargo mass

(A) In the case where in the scantlings of structural members of double bottom are determined by the formula prescribed in the requirements of the Rule

(a) In each hold, the pressure which works on the ships bottom with mass of cargo or ballast water is to be not greater than the obtained with the following formulas.

The pressure, $9.81h_x\gamma(\mathrm{kN/m^2})$, which works on the considered hold is;

$$b+9.81(d_x-0.026L'\alpha_R-h_{BST})$$

The pressure, $9.81h'_x\gamma'(\mathrm{kN/m^2})$, which works on the adjacent hold is;

$$b'+9.81(d_x-0.026L'\alpha_R-h'_{BST})$$

h_x and h'_x : In each hold, stowage height to the cargo surface from the tank top at the center line (m). In any case, the height of the cargo surface cannot exceed that of the upper deck.

γ and γ' : In each cargo hold, design specific gravity of cargoes for the cargo hold which has the largest value under such loading conditions that two adjacent holds are empty or loaded simultaneously.

b and b' : The case in which a_j and a'_j satisfy the relationship defined by the following formula, b and b' take the absolute value of a_j and a'_j respectively. The absolute value cannot, however, exceed the design pressure given to the local structural member of double bottom where the member is reinforced to enable ship to carry such heavy cargoes as steel coils.

$$a_j a'_j = \max\{a_1 a'_1, a_2 a'_2, \cdots, a_m a'_m\}$$

a_j and a'_j : Differences in pressure of the considered hold and the adjacent hold in loading condition No. j taken from a population with the total of such m loading conditions that two adjacent holds are empty or loaded simultaneously, which work on the center line of the ships bottom by mass of cargo, ballast water and/or double bottom contents and by wave and still water corresponding to the draft (kN/m^2). In loading condition No. j, a_j and a'_j take respectively a_{jk} and a'_{jk} as obtained with the following formula if each difference in pressure of the considered hold and the adjacent hold has the same sign (i.e. plus or minus) in both cases where it added the pressure by wave to the pressure by still water and it subtracted the pressure by wave from the pressure by still water. In any case, it takes a downward force as a positive value.

$$a_{jk} a'_{jk} = \max\{a_{j1} a'_{j1}, a_{j2} a'_{j2}\}$$

a_{jk} and a'_{jk} : Differences in pressure of the considered hold and the adjacent hold in loading condition No. j which are obtained from the following formulas. In case where the pressure by wave is added to the pressure by still water, they are defined as a_{j1} and a'_{j1} respectively. The differences in pressure of the considered hold and the adjacent hold in case where the pressure by wave is subtracted from the pressure by still water are also defined as a_{j2} and a'_{j2}.

$$a_{j1} = p_j - 9.81(d_j + 0.026L')$$
$$a'_{j1} = p'_j - 9.81(d'_j + 0.026L')$$
$$a_{j2} = p_j - 9.81(d_j - 0.026L')$$
$$a'_{j2} = p'_j - 9.81(d'_j - 0.026L')$$

p_j and p'_j : In loading condition No. j, the pressure respectively in the considered hold and in the adjacent hold which arises at the center line of the ships bottom by the mass of cargo, ballast water and/or double bottom contents (kN/m^2).

d_j and d'_j : In loading condition No. j, draught at mid-hold position of cargo hold length l_H (m) of the considered hold and the adjacent hold respectively.

l_H, L' and α_R : As specified in 1. (1) (A)

d_x : The average value of d_j and d'_j (m)

h_{BST} and h'_{BST} : In the considered hold and the adjacent hold respectively, water heads of ballast water charged in the double bottom at the center line (m). In any case, they cannot exceed the height of the double bottom

(b) The maximum allowable cargo mass, $W_{MAX}(\mathrm{ton})$, is to be not greater than the obtained with the following formula.

$$\gamma f_1(h_x)+\gamma' f_2(h'_x)$$

$f_1(h_x)$ and $f_2(h'_x)$: Function, in the considered hold and the adjacent hold respectively, which shows the relationship between the stowage height of the cargo (m) at the center line and the volume (m^3) of the cargo loaded in the hold. In this case, the cargo may be uniformly supposed to be loaded under level surface.

(B) In the case where the scantlings of structural members of double bottom are determined by direct calculations;

(a) In each hold, the pressure which works on the ships bottom with mass of cargo or ballast water is to be not greater than the obtained with the following formulas.

The pressure, $9.81h_x\gamma(\mathrm{kN/m^2})$, which works on the considered hold is;

$$b+10.0(d_x-0.25H_w\alpha_{DC}-h_{BST})$$

The pressure, $9.81h'_x\gamma'(\mathrm{kN/m^2})$, which works on the adjacent hold is;

$$b'+10.0(d_x-0.25H_w\alpha_{DC}-h'_{BST})$$

h_x, h'_x, γ, γ', d_x, h_{BST} and h'_{BST} : As specified in (A)

b and b' : As specified in (A), in calculating the values of a_{j1}, a'_{j1}, a_{j2} and a'_{j2} the following formulas are applied respectively.

$$a_{j1}=p_j-10.0(d_j+0.25H_w)$$
$$a'_{j1}=p'_j-10.0(d'_j+0.25H_w)$$
$$a_{j2}=p_j-10.0(d_j-0.25H_w)$$
$$a'_{j2}=p'_j-10.0(d'_j-0.25H_w)$$

p_j and p'_j : As specified in (A). In calculating the pressure which arises by the mass of cargo, the density of cargo and the shape of cargo surface which were applied in direct calculations may be, however, taken into consideration.

d_j and d'_j : As specified in (A)

H_w and α_{DC} : As specified in **Par 1** (1) (A)

(b) The maximum allowable cargo mass, $W_{MAX}(\mathrm{ton})$, is to be not greater than that obtained from the following formula.

$$\gamma f_1(h_x)+\gamma' f_2(h'_x)$$

$f_1(h_x)$ and $f_2(h'_x)$: As specified in (A)

(2) Minimum allowable cargo mass

(A) In the case where the scantlings of structural members of double bottom are determined by the formula prescribed in the requirements of the Rule

(a) In each hold, the pressure which works on the ships bottom by mass of cargo or ballast water is be not less than the obtained with the following formulas.

The pressure, $9.81h_x\gamma(\mathrm{kN/m^2})$, which works on the considered hold is;

$$-b+9.81(d_x+0.026L'\alpha_R-h_{BST})$$

The pressure, $9.81h'_x\gamma'\ (\mathrm{kN/m^2})$, which works on the adjacent hold is;

$-b'+9.81(d_x+0.026L'\alpha_R-h'_{BST})$

h_x, h'_x, γ, γ', b, b', d_x, L', α_R, h_{BST} and h'_{BST} : As specified in (1) (B)

(b) The minimum allowable cargo mass, $W_{MIN}(\mathrm{ton})$, is to be not less than the obtained with the following formula.

$\gamma f_1(h_x)+\gamma' f_2(h'_x)$

$f_1(h_x)$ and $f_2(h'_x)$: As specified in (1) (A)

(B) In the case where the scantlings of structural members of double bottom are determined by direct calculations

(a) In each hold, the pressure which works on the ships bottom with mass of cargo or ballast water is to be not greater than the obtained with the following formulas.

The pressure, $9.81h_x\gamma\ (\mathrm{kN/m^2})$, which works on the considered hold is;

$b+10.0(d_x+0.25H_w\alpha_{DC}-h_{BST})$

The pressure, $9.81h'_x\gamma'\ (\mathrm{kN/m^2})$, which works on the adjacent hold is;

$b'+10.0(d_x+0.25H_w\alpha_{DC}-h'_{BST})$

h_x, h'_x, γ, γ', d_x H_w, α_{DC}, h_{BST} and h'_{BST} : As specified in (1) (B)

b and b' : In the case where a_j and a'_j satisfy the relationship defined by the following formula, b and b' take the value of a_j and a'_j respectively. The absolute values of b and b' cannot, however, exceed the design pressure given to the local structural member of double bottom where the member is reinforced to enable ship to carry such heavy cargoes as steel coils.

$$|a_j|\,a'_j=\min\{|a_1|a'_1,|a_2|a'_2,\cdots,|a_m|a'_m\}$$

a_j and a'_j : Differences in pressure of the considered hold and the adjacent hold in loading condition No. j taken from a population with the total of such m loading conditions that two adjacent holds are empty or loaded simultaneously, which works on the center line of the ships bottom by mass of cargo, ballast water and/or double bottom contents and by wave and still water corresponding to the draft ($\mathrm{kN/m^2}$). In loading condition No. j, a_j and a'_j take respectively a_{jk} and a'_{jk} as obtained with the following formulas if each difference in pressure of the considered hold and the adjacent hold has the same sign (i.e. plus or minus) in both cases where it added the pressure by wave to the pressure by still water and it subtracted the pressure by wave from the pressure by still water. In any case, it takes a downward force as a positive value.

$$|a_{jk}|\,a'_{jk}=\min\{|a_{j1}|a'_{j1},|a_{j2}|a'_{j2}\}$$

a_{jk} and a'_{jk} : Differences in pressure of the considered hold and adjacent hold in loading condition No. j, which are obtained from the following formulas. In case where the pressure by wave is added to the pressure by still water they are defined as a_{j1} and a'_{j1} respectively. The differences in pressure of the considered hold and the adjacent hold in case where the pressure by wave is subtracted from the pressure by still water are also defined as a_{j2} and a'_{j2}.

$$a_{j1} = p_j - 10.0(d_j + 0.25H_w)$$
$$a'_{j1} = p'_j - 10.0(d'_j + 0.25H_w)$$
$$a_{j2} = p_j - 10.0(d_j - 0.25H_w)$$
$$a'_{j2} = p'_j - 10.0(d'_j - 0.25H_w)$$

p_j and p'_j : As specified in (1) (B). In calculating the pressure which arises by the mass of cargo, the density of cargo and the shape of cargo surface which were applied in direct calculations may be, however, taken into consideration.

d_j and d'_j : As specified in (1) (B)

(b) The minimum allowable cargo mass, $W_{MIN}(\mathrm{ton})$, is to be not less than that obtained from the following formula.

$$\gamma f_1(h_x) + \gamma' f_2(h'_x)$$

$f_1(h_x)$ and $f_2(h'_x)$: As specified in (1) (B)

3. Notwithstanding the provisions of **Par 1** above, for ships of BC-A, BC-B and BC-C specified in **Ch 3, 201. 3** of the Rules, the maximum allowable cargo mass W_{MAX} and the minimum required cargo mass W_{MIN} for the cargo hold may be determined by the following formulae. (See **Fig 1**)

$$W_{MAX} = W_{\max}(0) + 1.025\,V\frac{d_x}{h}(\mathrm{ton})$$

However, is in no case to be greater than maximum cargo mass $M_D(\mathrm{ton})$

$W_{MIN} = W_{\min}(0) + 1.025\,V\frac{d_x}{h}(ton)$ However, is in no case to be less than 0.

$$W_{\max}(0) = \max\left\{W_{\max}(d_i) - 1.025\,V\frac{d_i}{h}\right\}$$

$$W_{\min}(0) = \min\left\{W_{\min}(d_i) - 1.025\,V\frac{d_i}{h}\right\}$$

$W_{\max}(d_i)$, $W_{\min}(d_i)$: Maximum allowable cargo mass and minimum required cargo mass corresponding to the draught, d_i determined based on the loading condition No. I of loading conditions applied in accordance with the type of ship (ton)

d_i : Draught in the loading condition No. i, at mid-hold position of cargo hold length (m)

V : Volume of the cargo hold excluding volume of the hatchway part (m^3)

h : Vertical distance from the top of inner bottom plating to upper deck plating at the ships centre line(m)

d_x : As specified in **Par 1** (1) (A)

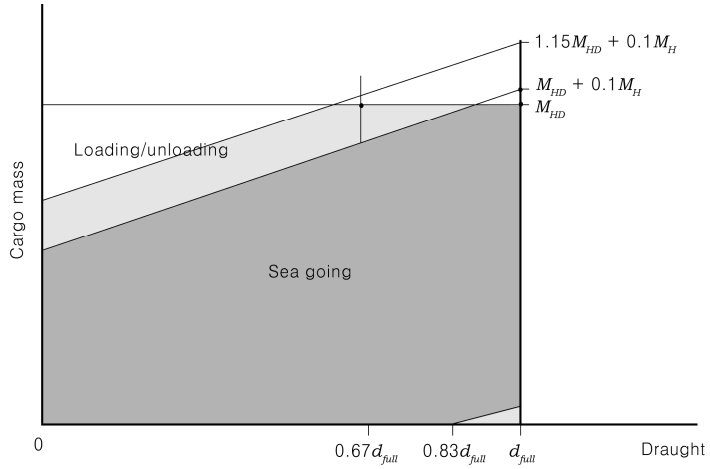


Fig 1 Maximum allowable cargo mass and minimum required cargo mass for a cargo hold(example for a loaded hold in ships of BC-A)

4. Notwithstanding the provisions of **Par 2** above, for ships of BC-A, BC-B and BC-C specified in **Ch 3, 201. 3** of the Rules, the maximum allowable cargo mass W_{MAX} and the minimum required cargo mass W_{MIN} for the adjacent two holds may be determined by the following formulae. (See **Fig 2**)

$$W_{MAX} = 2M_{Full} + 1.025(V_f + V_d)\frac{d_x - 0.67d}{h}(\mathrm{ton}),$$

However, is in no case to be greater than the maximum cargo mass M_D for each cargo hold.

$W_{MIN} = 1.025(V_f + V_d)\frac{d_x - d_{\min}}{h}(\mathrm{ton})$, However, is in no case to be less than 0.

M_{Full} : the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1.0 $1.0\mathrm{t/m^3}$) filled to the top of the hatch coaming. M Full is in no case to be less than the actual cargo mass(M_H) in a cargo hold corresponding to a homogeneously loaded condition at maximum draught

V_f and V_a : Volume of the forward and after cargo hold excluding volume of the hatchway part $(\mathrm{m^3})$

$d_{\min}$: $0.75d$ or draught in ballast conditions with the two adjacent cargo holds empty, whichever is greater(m)

5. In the case specified in **Par 3** and **4**, maximum allowable cargo mass and minimum required cargo mass corresponding to draught for loading/unloading conditions in harbour may be increased or decreased by 15 % of the maximum allowable mass for the cargo hold (in case specified in **Par 4** the maximum allowable mass for the two adjacent cargo hold) at designed maximum load draught in sea-going condition. However, maximum allowable mass is in no case to be greater than the maximum allowable cargo mass at designed maximum load draught for each cargo hold.

6. Where, notwithstanding **Par 1** and **4** above, the scantling of the double bottom structure is determined for the loading condition other than those given in **Par 1** or **3** above, maximum allowable and minimum required mass of cargo may be determined with that condition. Maximum allowable and minimum required mass of cargo being greater or less than the values given in **Par 1** and **2**, may be taken when the strength of the double bottom is determined by additional direct calculations and so on.

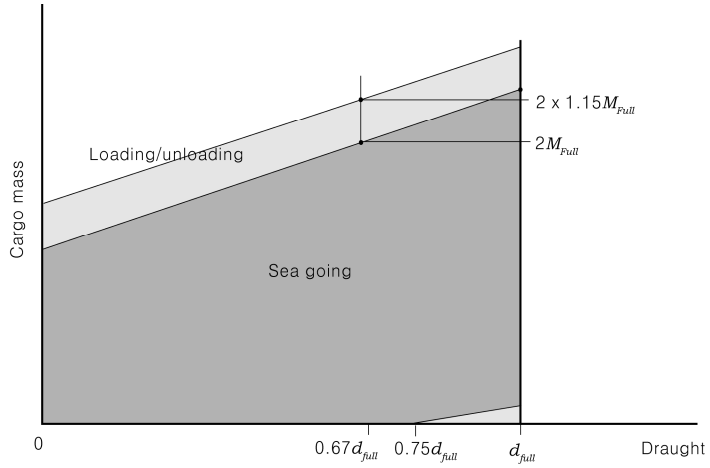


Fig 2 Maximum allowable cargo mass and minimum required cargo mass for two adjacent cargo holds(example)

7. In relation to **Par 1** to **6** above, the following notice on referring to maximum allowable and minimum required mass of cargo is to be described in loading manual.

"Where ship engages in a service to carry such hot coils or heavy cargoes that have some adverse effect on the local strength of the double bottom and that the loading is not described as cargo in Loading Manual, maximum allowable and minimum required mass of cargo are to be considered specially."

8. Typical loading/unloading sequences required in **Pt 3, Appendix 3-1, 3** (1) (F) of the Guidance, are approved by the Society. Such sequences contain the following loading conditions. However, as for the loading conditions except the following (2), only in case these are specified as ones of the design conditions, these may be included in the loading manual.

(1) Alternate loading condition regulated in **Pt 3, Appendix 3-1**, **3** (1) (F) (a) of the Guidance
(2) Homogeneous loading condition regulated in **Pt 3, Appendix 3-1, 3** (1) (F) (b) of the Guidance
(3) Short voyage condition regulated in **Pt 3, Appendix 3-1, 3** (1) (F) (d) of the Guidance
(4) Multiple port loading/unloading condition regulated in **Pt 3, Appendix 3-1, 3** (1) (F) (e) of the Guidance
(5) Deck cargo condition regulated in **Pt 3, Appendix 3-1, 3** (1) (F) (f) of the Guidance
(6) Block loading (partial loading condition; loaded cargo in over two adjacent holds).

9. Each step of a sequence required in **Par 8** above is specified as follows. A step is defined as each time of changes of the loading equipment position to a new hold.

(1) Each step between commencement of cargo loading in the ballasted condition and the planed loading condition in case of loading cargo.
(2) Each step between commencement of discharging cargo in the planed loading condition and the ballast condition at departure in case of discharging cargo.

10. Each step of sequences specified in **Par 8** above is acceptable within the allowable limits of longitudinal bending moments and shear forces.

11. In addition to **Par 7** above, loading manual is to contain the loading/unloading sequence summary forms as specified in **Pt 3, Appendix 3-1, 3** (1) (F) (g), **Table 4** of Guidance, and to include the following notices.

"Where loading/unloading rather than those included in the design plans or in the loading manual, new loading/unloading sequences are to be developed with the prescribed forms, paying attention to loading rate, the deballasting capability, longitudinal strength, and maximum allowable and minimum required mass of cargo and double bottom contents." ⚓

Annex 7-5 Additional Requirements for Existing Bulk Carriers

1. Scantling of the transverse watertight corrugated bulkhead between cargo holds No.1 and 2, with cargo hold No.1 flooded, for existing bulk carriers

(1) Application and definitions

(A) These requirements apply to all bulk carriers of 150 m in length(L_f) 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:

(a) 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 **Ch 3, Sec 12** of the Rules.

(b) 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 **Ch 3, Sec 12** of the Rules.

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

(C) Steel renewal and/or reinforcements are required as per (6).

(D) 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 1.2 to be corrected for different cargo densities.

(2) Load model

(A) General

(a) 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.

(b) 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:

(i) homogeneous loading conditions;

(ii) non homogeneous loading conditions.

(c) 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.

(B) Bulkhead corrugation flooding head

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

(a) For ships less than 50,000 *tonnes* deadweight with Type B freeboard : $d_f = 0.95D$

(b) For ships other than shown in (a) :

$d_f = D$

(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 $T - T_r$.

(C) Pressure in the flooded hold

(a) Bulk cargo loaded hold

Two cases are to be considered, depending on the values of d_1 and d_f, but, d_1 (See Fig **1**) being a distance from the baseline given, in m, by:

$$d_1 = \frac{M_c}{\rho_c l_c B} + \frac{V_{LS}}{l_c B} + (h_{HT} - h_{DB})\frac{b_{HT}}{B} + h_{DB} \quad (\mathrm{m})$$

where :

M_c = mass of cargo, in hold No.1(*ton*)

ρ_c = bulk cargo density (t/m^3)

l_c = length of hold No. 1(m)

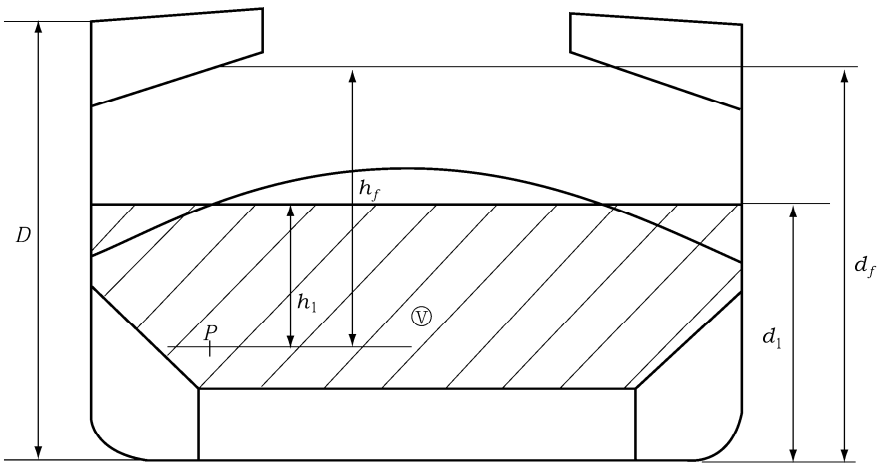
B = ship's breadth amidship (m)

V_{LS} = volume of the bottom stool above the inner bottom (m^3)

h_{HT} = height of the hopper tanks amidship from the baseline (m)

h_{DB} = height of the double bottom (m)

b_{HT} = breadth of the hopper tanks amidship (m)



V : Volume of cargo
P : Calculation point

Fig 1 Measurement of d_f, h_1 and h_f

(i) for $d_f \geq d_1$

① At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $P_{c,f}$ is given by:

$$P_{c,f} = \rho g h_f \quad (\mathrm{kN/m^2})$$

where :

ρ = 1.025 $\mathrm{t/m^3}$, sea water density ($\mathrm{t/m^3}$)

g = 9.81 $\mathrm{m/s^2}$, gravity acceleration

h_f = flooding head as defined in (B)

② At each point of the bulkhead located at a distance lower than d_1 from the base-line, the pressure $P_{c,f}$ is given by:

$$P_{c,f} = \rho g h_f + [\rho_c - \rho(1 - perm)] g h_1 \tan^2\gamma \quad (\mathrm{kN/m^2})$$

ρ, g, h_f = as given above ①

ρ_c = bulk cargo density ($\mathrm{t/m^3}$)

$perm$ = 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 $\mathrm{t/m^3}$),

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

γ = 45° - (ϕ/2)

ϕ = angle of repose of the cargo, in degrees, and may generally be taken as 35° for iron ore and be taken as 25° for cement

③ The force $F_{c,f}$ acting on a corrugation is given by:

$$F_{c,f} = S_1\left[\frac{\rho g(d_f - d_1)^2}{2} + \frac{\rho g(d_f - d_1) + (P_{c,f})_{le}}{2}(d_1 - h_{DB} - h_{LS})\right] \quad (\mathrm{kN})$$

where :

S_1 = spacing of corrugations(m) (See **Fig 2**)

ρ and g = as specified ② above

d_f = as specified in (B)

$(P_{c,f})_{le}$= pressure at the lower end of the corrugation ($\mathrm{kN/mm^2}$)

d_1 and h_{DB} = as specified in (a)

h_{LS} = height of the lower stool (m) from the inner bottom.(m)

(ii) for $d_f < d_1$

① At each point of the bulkhead located at a distance between d_f and d_1 from the baseline, the pressure $P_{c,f}$ is given by:

$$P_{c,f} = \rho_c g h_1 \tan^2\gamma \quad (\mathrm{kN/m^2})$$

where :

ρ_c, g, h_1 and γ = as specified in (i)

② At each point of the bulkhead located at a distance lower than d_f from the base-line, the pressure $P_{c,f}$ is given by:

$$P_{c,f} = \rho g h_f + [\rho_c h_1 - \rho(1 - perm)h_f]g\tan^2\gamma \quad (\mathrm{kN/m^2})$$

where :

ρ, g, h_f, ρ_c, h_1, $perm$ and γ = as specified in (i) above

③ The force $F_{c,f}$ acting on a corrugation is given by:

$$F_{c,f} = S_1\left[\frac{\rho_c g(d_1 - d_f)^2}{2}\tan^2\gamma + \frac{\rho_c g(d_1 - d_f)\tan^2\gamma + (P_{c,f})_{le}}{2}(d_1 - h_{DB} - h_{LS})\right] \quad (\mathrm{kN})$$

where :

S_1, ρ_c, g, γ, $(P_{c,f})_{le}$ and h_{LS} = as specified in (i) above

d_1 and h_{DB} = as specified in (a)

d_f= as specified in (B)

(b) Pressure in the flooded empty hold

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

$$P_f = \rho g h_f \quad (\mathrm{kN/m^2})$$

The force F_f acting on a corrugation is given by the following formulae:

$$F_f = S_1 \rho g \frac{(d_f - d_{DB} - h_{LS})^2}{2} \quad (\mathrm{kN})$$

where :

S_1, g, ρ and h_{LS} = as specified in (i) above

d_1 and h_{DB} = as specified in (a)

d_f = as specified in (B)

(D) Pressure in the non-flooded bulk cargo loaded hold

(a) At each point of the bulkhead, the pressure P_c is given by:

$$P_c = \rho_c g h_1 \tan^2\gamma \quad (\mathrm{kN/m^2})$$

where :

ρ_c, g, h_1 and γ = as specified in (C), (a) (i) above

(b) The force F_c acting on a corrugation is given by the following formula:

$$F_c = S_1 \rho_c g \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \tan^2\gamma \quad (\mathrm{kN})$$

where :

ρ_c, g, S_1, h_{LS} and γ = as specified in (C), (a) (i) above

d_1 and h_{DB} = as specified in (C), (a) above

(E) Resultant pressure and load

(a) Homogeneous loading conditions

(i) At each point of the bulkhead structures, the resultant pressure P, to be considered for the scantlings of the bulkhead is given by:

$$P = P_{c,f} - 0.8P_c \quad (\mathrm{kN/m^2})$$

(ii) The resultant force F acting on a corrugation is given by:

$$F = F_{c,f} - 0.8F_c \quad (\mathrm{kN})$$

(b) Non homogeneous loading conditions

(i) At each point of the bulkhead structures, the resultant pressure P to be considered for the scantlings of the bulkhead is given by:

$$P = P_{c,f} \quad (\mathrm{kN/m^2})$$

(ii) The resultant force F acting on a corrugation is given by:

$$F = F_{c,f} \quad (\mathrm{kN})$$

(iii) In case hold No.1, in non homogeneous loading conditions, is not allowed to be loaded, the resultant pressure P to be considered for the scantlings of the bulkhead and the resultant force F acting on a corrugation is given by:

$$P = P_f \quad (\mathrm{kN/m^2})$$

$$F = F_f \quad (\mathrm{kN})$$

(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 (A) and (B). The M and Q values are to be used for the checks in (4).
(A) Bending moment
The design bending moment M for the bulkhead corrugations is given by:

$$M = \frac{Fl}{8} \quad (\text{kN-m})$$

where :
F = resultant force as specified in (2) (E)
l = span of the corrugation (m) (See **Fig 2** and **3**)

(B) Shear force
The shear force Q at the lower end of the bulkhead corrugations is given by:

$$Q = 0.8F \quad (\text{kN})$$

where :
F and l = as specified in (A) above

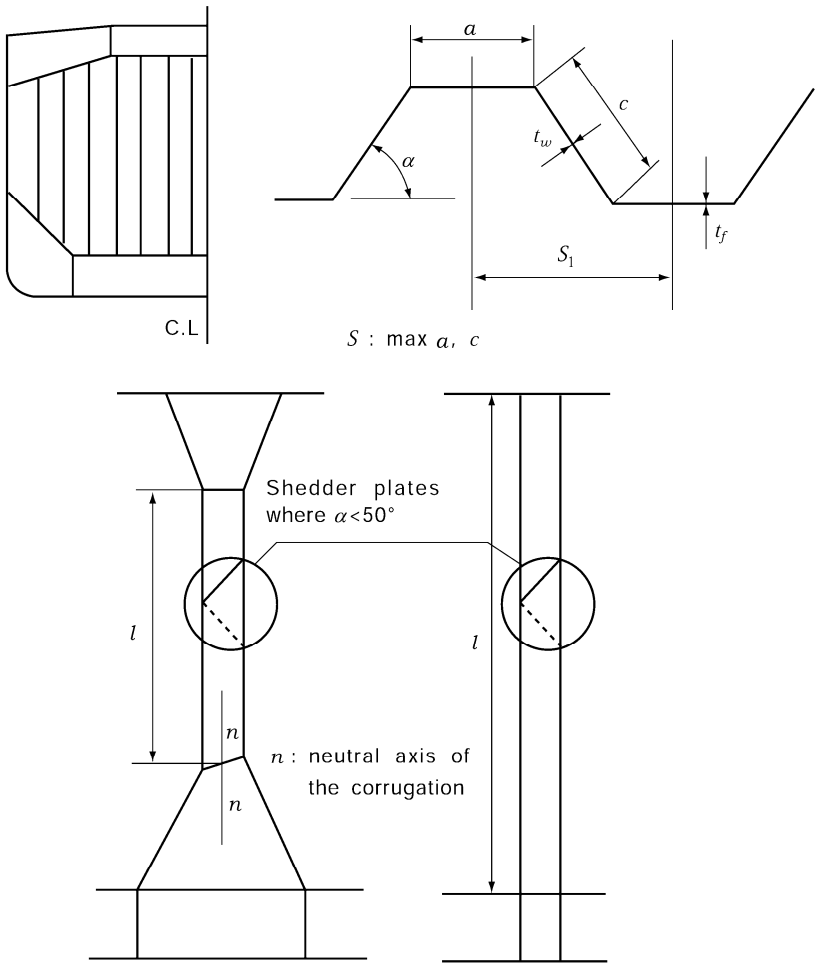
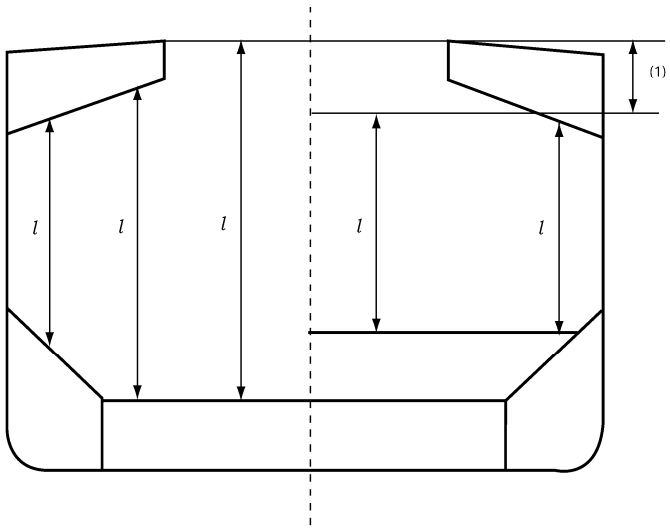


Fig 2 Measurement of S and l



(Note)
(1) For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to.
(1) For rectangular stool : 2 times the depth of corrugation
(2) For other than shown in (1) : 3 times the depth of corrugation

Fig 3 Measurement of corrugated span l

(4) Strength criteria
(A) General
The following criteria are applicable to transverse bulkheads with vertical corrugations (See **Fig 2**).
(a) Requirements for local net plate thickness are given in (B), (E), (F) and (G).
(b) Where the corrugation angle α shown in **Fig 2** is less than 50°, horizontal row of staggered shedder plates is to be fitted at approximately mid depth of the corrugations 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.
(c) The thicknesses of the lower part of corrugations considered in the application of (B) and (C) 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 $0.15l$.
(d) The thicknesses of the middle part of corrugations considered in the application of (B) and (D) 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 $0.3l$.
(B) Bending capacity and shear stress
(a) The bending capacity is to comply with the following relationship:

$$\frac{M}{0.5Z_{le}\sigma_{a,le}+Z_m\sigma_{a,m}}\times 10^3 \le 1.0$$

where :
M = bending moment(kN-m), as specified in (3) (A) above.
Z_{le} = section modulus of one half pitch corrugation at the lower end of corrugations, as specified in (C) (cm^3)
Z_m = section modulus of one half pitch corrugation at the mid-span of corrugations as specified in (D) (cm^3)
$\sigma_{a,le}$ = allowable stress at the lower end of corrugations as specified in (E)
$\sigma_{a,m}$ = allowable stress at the mid-span of corrugations as specified in (E).

(i) In no case Z_m is to be taken greater than the lesser of $1.15Z_{le}$ and $1.15Z'_{le}$ for calculation of the bending capacity, Z'_{le} being defined below.
① In case effective shedder plates are fitted:
ⓐ Shedder plates are not knuckled;
ⓑ Shedder plates are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;
ⓒ Shedder plates are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating;
② In case effective gusset plates are fitted:
ⓐ Gusset plates are fitted in line with the stool side plating;
ⓑ Gusset plates have material properties at least equal to those provided for the flanges,

(ii) the section modulus Z_{le}, is to be taken not larger than the value Z'_{le} given by :

$$Z'_{le} = Z_g + \frac{Qh_g - 0.5h_g^2 S_1 P_g}{\sigma_a} \times 10^3 \quad (\mathrm{cm}^2)$$

where:

Z_g = section modulus of one half pitch corrugation, according to (D), in way of the upper end of shedder or gusset plates, as applicable

Q = shear force as given in (3) (B)

h_g = height of shedder or gusset plates (m), as applicable (See **Fig 4** (1), (2), (3) and (4))

S_1 = as specified in (2) (C) (a)

P_g = resultant pressure ($\mathrm{kN/m^2}$) as defined in (2) (E), calculated in way of the middle of the shedder or gusset plates, as applicable

σ_a = allowable stress ($\mathrm{N/mm^2}$) as specified in (E).

(b) 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 $\sin\alpha$, where α being the angle between the web and the flange. (See **Fig 2**)

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

(d) The section moduli of corrugations are to be calculated on the basis of the requirements given in (C) and (D).

(C) Section modulus at the lower end of corrugations
The section modulus is to be calculated with the compression flange having an effective flange width b_{eff}, not larger than as given (F) (a).
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 (B) are fitted (See **Fig 4** (1) and (2)), when calculating the section modulus of corrugations at the lower end (cross-section in **Fig 4** (1) and (2) ①), the area of flange plates ($\mathrm{cm^2}$), may be increased by not to be taken greater than

$$2.5a\sqrt{t_f t_{sh}}\sqrt{\frac{\sigma_{Fsh}}{\sigma_{Ffl}}}$$

but, it is to be less than $2.5at_f$.

a = width (m) of the corrugation flange (See **Fig 2**)

t_{sh} = net shedder plate thickness (mm)

t_f = net flange thickness (mm)

σ_{Fsh}= minimum upper yield stress ($\mathrm{N/mm^2}$) of the material used for the shedder plates

σ_{Ffl}= minimum upper yield stress ($\mathrm{N/mm^2}$) of the material used for the corrugation flanges.

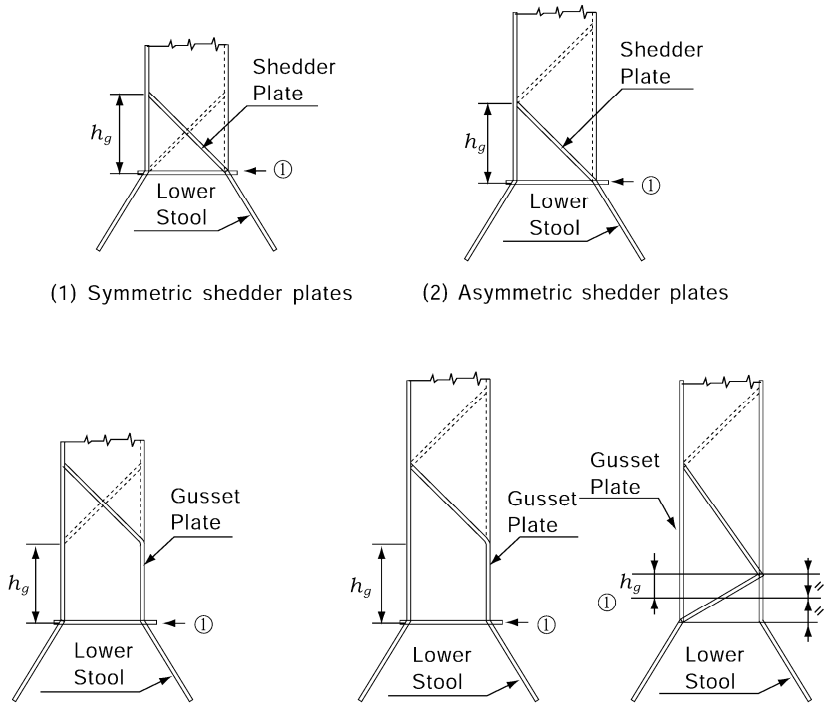
(b) Provided that effective gusset plates, as defined in (B), are fitted (See **Fig 4** (3) and (4)), when calculating the section modulus of corrugations at the lower end (cross-section in **Fig 4** (3) and (4) ①), the area of flange plates($\mathrm{cm^2}$), may be increased by $7h_g t_{gu}$.

h_g = height of gusset plate (m) (See **Fig 4** (3) and (4)), not to be taken greater than $\frac{10}{7}S_{gu}$

S_{gu} = width of the gusset plates(m)

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

t_f = net flange thickness based on the as built condition.(m)



(1) Symmetric shedder plates (2) Asymmetric shedder plates

(3) Symmetric gusset/shedder plate (4) Asymmetric gusset/shedder plate

Fig 4 Shedder plates and Gusset plates

(c) If the corrugation webs are welded to a sloping stool top plate, which is at an angle not less than 45° 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° the effectiveness of the web may be obtained by linear interpolation between 30 % for 0° and 100 % for 45°

(D) 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 (F) (a).

(E) Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a, given by:

$$\sigma_a = \sigma_y \quad (\mathrm{N/mm^2})$$
$$\tau_a = 0.50\sigma_y \quad (\mathrm{N/mm^2})$$

where :

σ_y = minimum upper yield stress of the material.($\mathrm{N/mm^2}$)

(F) Effective compression flange width and shear buckling check

(a) Effective width of the compression flange of corrugations

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

$$b_{ef} = C_e a \quad (\mathrm{m})$$

where :

for $\beta > 1.25$: $C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2}$

for $\beta \leq 1.25$: $C_e = 1.0$

$$\beta = \frac{a}{t_f}\sqrt{\frac{\sigma_y}{E}} \times 10^3$$

t_f = net flange thickness (mm)

a = width of the corrugation flange (m) (See **Fig 2**)

σ_y = minimum upper yield stress of the material ($\mathrm{N/mm^2}$)

E = modulus of elasticity ($\mathrm{N/mm^2}$), to be assumed equal to 2.06 × 10^5 $\mathrm{N/mm^2}$for steel

(b) 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 obtained by the following:

$\tau_c = \tau_E$ when : $\tau_E \leq 0.5\tau_y$

$\tau_c = \tau_y\left(1 - \frac{\tau_y}{4\tau_E}\right)$ when : $\tau_E > 0.5\tau_y$

where :

τ_y = shear stress of the material ($\mathrm{N/mm^2}$)

$\sigma_y/\sqrt{3}$

τ_E = elastic buckling stress ($\mathrm{N/mm^2}$)

$$\tau_E = 0.9k_t E\left(\frac{t}{1000c}\right)^2 \quad (\mathrm{N/mm^2})$$

where :

k_t = 6.34

t = net thickness (mm) of corrugation web (mm)

c = breadth of corrugation web (See **Fig 2**)

σ_y, E = as specified in (a) above.

(G) Local net plate thickness

(a) The bulkhead local net plate thickness, t_{net} (mm) is given by:

$$t_{net} = 14.9 S_w \sqrt{\frac{P}{\sigma_y}} \quad (\mathrm{mm})$$

where :

S_w = plate width (m) to be taken equal to the width of the corrugation flange or web, whichever is the greater (See **Fig 2**)

P = resultant pressure ($\mathrm{kN/m^2}$), as defined in (2) (E), 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 shedders, if shedder or gusset/shedder plates are fitted.

σ_y = minimum upper yield stress of the material($\mathrm{N/mm^2}$)

(b) When the thicknesses of the flange and web are different :

(i) The net thickness of the narrower plating is not to be taken less than the following values:

$$t_n = 14.9 S_n \sqrt{\frac{P}{\sigma_y}} \quad (\mathrm{mm})$$

where :

S_n = the width of the narrower plating.(m)

P and σ_y = as specified in (a) above.

(ii) The net thickness of the wider plating is not to be taken less than the maximum of the following values:

$$t_{w1} = 14.9 S_w \sqrt{\frac{P}{\sigma_y}} \quad (\mathrm{mm}), \qquad t_{w2} = \sqrt{\frac{440 S_w^2 P}{\sigma_y} - t_{np}^2} \quad (\mathrm{mm})$$

where :

t_{np} = the lesser value of the between actual net thickness of the narrower plating and t_{w1}.

(5) Local details

(A) As applicable, the design of local details is to comply with the Society's requirements 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.

(B) In particular, the thickness and stiffening of gusset and shedder plates, installed for Strengthening purposes, is to comply with the Society's requirements, on the basis of the load model in (2). Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society's requirements.

(6) Corrosion addition and steel renewal

(A) Steel renewal is required where the gauged thickness is less than $t_{\mathrm{net}} + 0.5$ mm, t_{net} being the thickness used for the calculation of bending capacity and shear stresses as given in (4)(B) or the local net plate thickness as given in (4) (G). Alternatively, reinforcing doubling strips may be used providing the net thickness is not dictated by shear strength requirements for web plates (See (4) (E) and (4) (F) (b)) or by local pressure requirements for web and flange plates (See (4) (G)).

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

(C) 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.

(D) For $0.8(\sigma_{Ffl}t_{fl}) \geq \sigma_{Fs}t_{st}$

σ_{Ffl}= minimum upper yield stress(N/mm^2) of the material used for the corrugation flanges

σ_{Fs} = minimum upper yield stress(N/mm^2) 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 (C) above. The above flange thickness dictated by local pressure requirements (See (4) (G)) need not be considered for this purpose

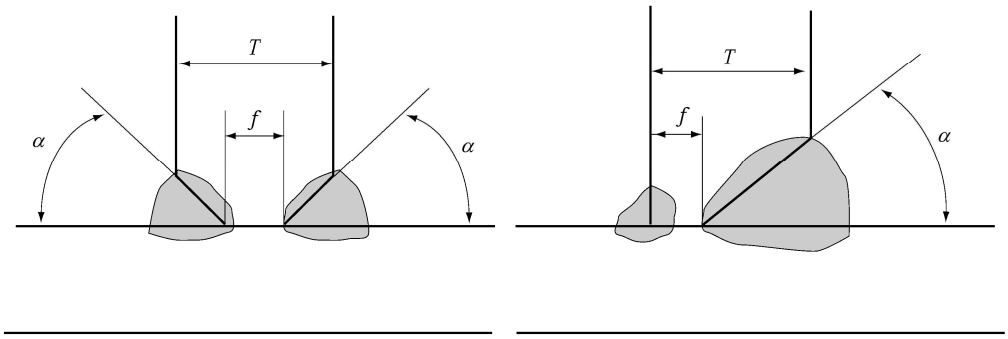
t_{st} = as built thickness of the lower stool side plating or floors (if no stool is fitted) (mm)

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

(b) 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 **Fig 5**).

(E) 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.

(F) 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 **Fig 5**).



Root Face f : 3mm ~ T/3mm
Groove Angle α : 40° ~ 60°

Fig 5 Deep penetration weld

(G) Guidance on renewal/reinforcement of vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2

(a) The need for renewal or reinforcement of the vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2 will be determined by the classification society on a case by case basis using the criteria given in association with the most recent gaugings and findings from survey.

(b) It will take into account the following:

(i) Scantlings of individual vertical corrugations will be assessed for reinforcement / re-

newal based on thickness measurements obtained in accordance with **Pt 1, Annex 1-5, Table 8** at their lower end, at mid-depth and in way of plate thickness changes in the lower 70 %. These considerations will take into account the provision of gussets and shedder plates and the benefits they offer, provided that they comply with (4) (B) and (A) to (F).

(ii) Permissible levels of diminution will be determined and appropriate measures taken in accordance with (A) and (B).

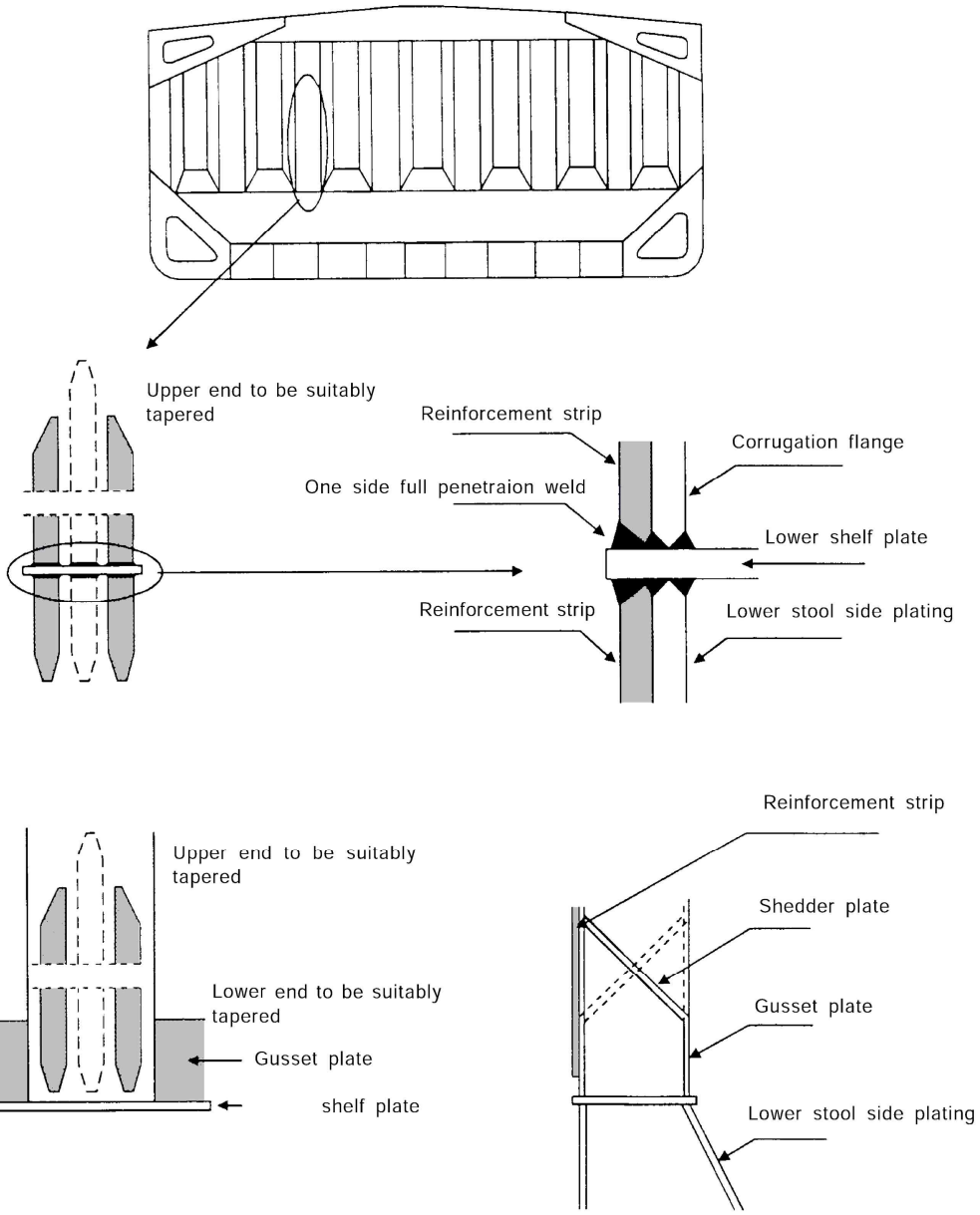
(c) Where renewal is required, the extent of renewal is to be shown clearly in plans. The vertical distance of each renewal zone is to be not less than 15 % of the vertical distance between the upper and lower end of the corrugation measured at the ship's centreline.

(d) Where the reinforcement is accepted by adding strips, the length of the reinforcing strips is to be sufficient to allow it to extend over the whole depth of the diminished plating. In general, the width and thickness of strips should be sufficient to comply with the (A) to (F) requirements. The material of the strips is to be the same as that of the corrugation plating. The strips are to be attached to the existing bulkhead plating by continuous fillet welds. The strips are to be suitably tapered or connected at ends in accordance with Class Society practice. (See **Fig 6**)

(e) Where reinforcing strips are connected to the inner bottom or lower stool shelf plates, one side full penetration welding is to be used. When reinforcing strips are fitted to the corrugation flange and are connected to the lower stool shelf plate, they are normally to be aligned with strips of the same scantlings welded to the stool side plating and having a minimum length equal to the breadth of the corrugation flange.

(f) A general arrangement of structural reinforcement is given by **Fig 6.**

(7) The flow chart to asses 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 may refer to the **Fig 7.** However, where the resultant pressure specified in above (2) (E) has the highest value for cargo density(ρ_c) being 1.78 t/m^3, this flow chart may not be applied.



(Note)

1. Square or trapezoidal corrugations are to be reinforced with plate strips fitted to each corrugation flange sufficient to meet the requirements of 1 (4) (A) to (F).
2. The number of strips fitted to each corrugation flange is to be sufficient to meet the requirements 1 (4).
3. The shedder plate may be fitted in one piece or prefabricated with a welded knuckle (gusset plate).
4. Gusset plates, where fitted, are to be welded to the shelf plate in line with the flange of the corrugation, to reduce th stress concentrations at the corrugation corners. Ensure good alignment between gusset plate, corrugation flange and lower stool sloping plate. Use deep penetration welding at all connections. Ensure start and stop of welding is as far away as practically possible from corners of corrugation.
5. Shedder plates are to be attached by on side full penetration welds onto backing bars.
6. Shedder and gusset plates are to have a thickness equal to or greater than the original bulkhead thickness. Gusset plate is to have a minimum height(on the vertical part) equal to half of the width of the corrugation flange. Shedders and gussets are to be same material as flange material.

Fig 6 Example of general arrangement of structural reinforcement

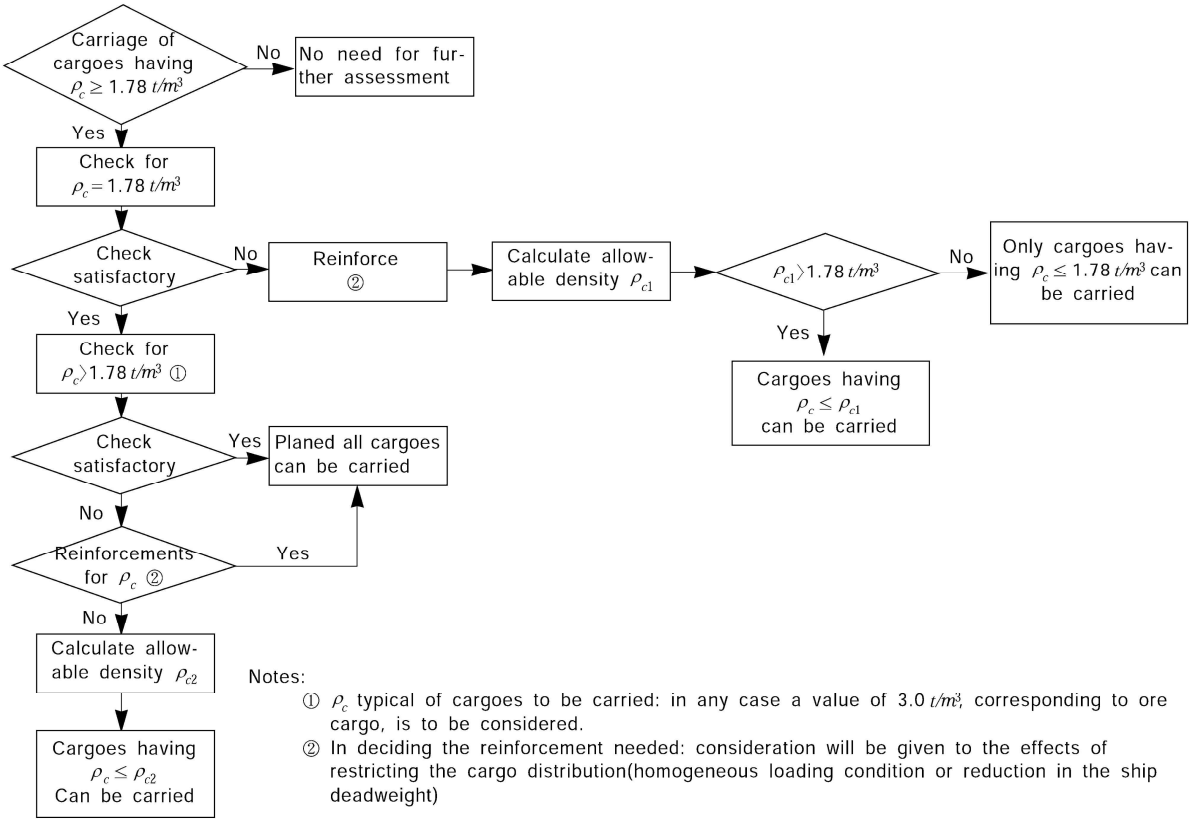


Fig 7 Flow chart to assess capability of carriage of high density cargoes on existing bulk carriers according to the strength of transverse bulkhead

2. Evaluation of Allowable Hold Loading of Cargo Hold No. 1 with Cargo Hold No. 1 Flooded, for Existing Bulk Carrier

(1) Application and definitions

(A) These requirements apply to all bulk carriers of 150 m in length and above, in the for most 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, where:

(a) 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 **Ch 3, Sec 11** of the Rules.

(b) 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 **Ch 3, Sec 11** of the Rules.

(B) Early completion of a special survey coming due after 1 July 1998 to postpone compliance is not allowed.

(C) The loading in cargo hold No. 1 is not to exceed the allowable hold loading in flooded condition, calculated as per (4), using the shear capacity of the double bottom given in (3).

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

(2) Loading model

(A) General

(a) The loads to be considered as acting on the double bottom are considered by following
(i) the load by the external sea pressures
(ii) the combination of the cargo loads with those induced by the flooding of the hold.

(b) 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:
(i) homogeneous loading conditions;

(ii) non homogeneous loading conditions;
(iii) packed cargo conditions (such as steel mill products).

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

(B) Inner bottom flooding head

The flooding head h_f (See **Fig 8**) 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 d_f, in m, from the baseline equal to:

(a) for ships less than 50,000 tonnes deadweight with Type B freeboard : $0.95D$

(b) for ships except for (a) above : D

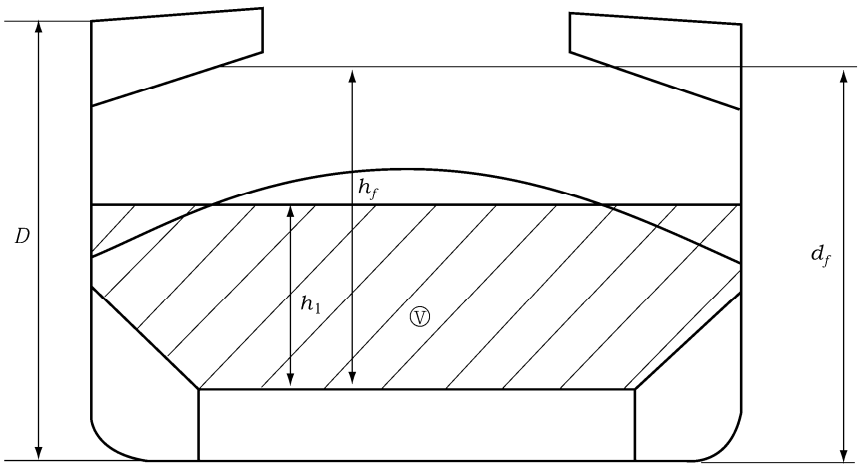


Fig 8 Measurement of d_f, h_1 and h_f

(3) Shear capacity of the double bottom of hold No. 1

(A) The shear capacity C of the double bottom of hold No. 1 is defined as the sum of the shear strength at each end of:

(a) 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 **Fig 9**).

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

(B) 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.

(C) 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.

(D) When the geometry and/or the structural arrangement of the double bottom are such to make the above (A) to (C) inadequate, to the Society's discretion, the shear capacity C of double bottom is to be calculated according to the Society's criteria.

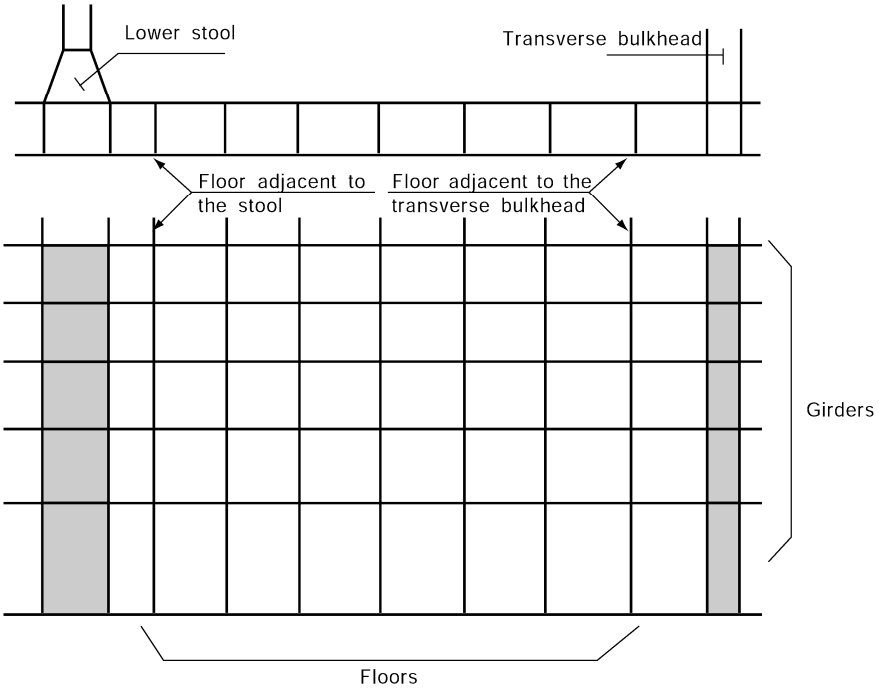


Fig 9 Considering floor and girder

(E) In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness t_{net}, in mm, is given by:

$$t_{net} = t - t_c \quad (\mathrm{mm})$$

where :

t = as built thickness of floors and girders.(mm)

t_c = corrosion diminution, equal to $2\,\mathrm{mm}$, in general ; a lower value of t_c may be adopted, provided that measures are taken, to the Society's satisfaction, to justify the assumption made.

(F) Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2} are given by the following expressions:

$$S_{f1} = A_f \frac{\tau_a}{\eta_1} \times 10^{-3} \quad (\mathrm{kN}), \quad S_{f2} = A_{f,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \quad (\mathrm{kN})$$

where:

A_f = sectional area of the floor panel adjacent to hoppers (mm^2)

$A_{f,h}$= net sectional area of the floor panels in way of the openings in the outmost bay(i.e. that bay which is closer to hopper)(mm^2)

τ_a = allowable shear stress $(\mathrm{N/mm}^2)$, to be taken equal to $\sigma_y / \sqrt{3}$

σ_y = minimum upper yield stress of the material $(\mathrm{N/mm}^2)$

η_1 = 1.1

η_2 = 1.2, η_2 may be reduced, as the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction

(G) Girder shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1} and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2} are given by the following expressions:

$$S_{g1} = A_g \frac{\tau_a}{\eta_1} \times 10^{-3} \quad (\mathrm{kN}), \qquad S_{g2} = A_{g,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \quad (\mathrm{kN})$$

where :

A_g = minimum sectional area of the girder panel adjacent to stools(or transverse bulkheads, if no stool is fitted) (mm^2)

$A_{g,h}$ = net sectional area of the girder panels in way of the largest opening in the outmost bay (i.e. that bay which is closest to stool, or transverse bulkhead, if no stool is fitted)(mm^2)

τ_a = allowable shear stress $(\mathrm{N/mm}^2)$, as given in (F) above.

η_1 = 1.10

η_2 = 1.15, η_2 may be reduced, at the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction

(4) Allowable hold loading

The allowable hold loading W is given by:

$$W = \rho_c V \frac{1}{F} \quad (ton)$$

where :

F = 1.05, however, 1.0 for steel mill products

ρ_c = cargo density for bulk cargoes , for steel products, ρ_c is to be taken as the density of steel $(\mathrm{t/m}^3)$

V = volume occupied by cargo at a level h_1 (m^3)

$$h_1 = \frac{X}{\rho_c g}$$

X is as follows.

(A) for bulk cargoes the lesser of X_1 and X_2 given by:

$$X_1 = \frac{Z + \rho g(E - h_f)}{1 + \frac{\rho}{\rho_c}(perm - 1)}, \qquad X_2 = Z + \rho g(E - h_f perm)$$

ρ = sea water density $(\mathrm{t/m}^3)$

g = 9.81 $\mathrm{m/s}^2$, gravity acceleration

E = ship immersion for flooded hold condition, $d_f - 0.1D$

d_f = as specified in (2) (B)

h_f = flooding head as defined in (2) (B)

$perm$ = cargo permeability, to be taken as 0.3 for ore

Z = the lesser of Z_1 and Z_2 given by

$$Z_1 = \frac{C_h}{A_{DB,h}}, \quad Z_2 = \frac{C_e}{A_{DB,e}}$$

C_h = shear capacity of the double bottom as defined in (3), considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (See (3) (F)) and, for each girder, the lesser of the shear strengths S_{f1} and S_{f2} (See (3) (G))

C_e = shear capacity of the double bottom as defined in (3), considering, for each floor, the shear strength S_{f1} (See (3) (F)) and, for each girder, the lesser of the shear strengths S_{f1} and S_{f2} (See (3) (G))

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i B_{DB,i}$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i (B_{DB} - S)$$

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

S_i = space of ith-floor(m)

$B_{DB,i}$ = $B_{DB} - S$ for floors whose shear strength is given by S_{f1} (See (3) (F)) $B_{DB,h}$ for floors whose shear strength is given by S_{f2} (See (3) (F))

B_{DB} = breadth of double bottom between hoppers (m) (See **Fig 10**)

$B_{DB,h}$ = distance between the two considered opening (m) (See **Fig 10**)

S = spacing of double bottom longitudinals adjacent to hoppers (m)

(B) for steel products, X may be taken as X_1, using $perm$ = 0

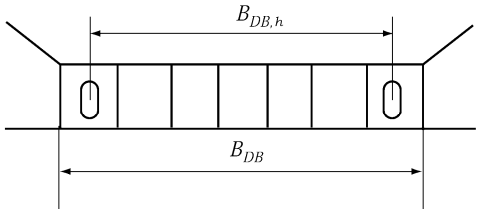


Fig 10 Measurement of $B_{DB,h}$ and B_{DB}

3. Damage Stability

(1) Bulk carriers which are subject to compliance with **Pars 1** and **2** shall, when loaded to the summer loadline, be able to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in **SOLAS regulation XII 4.3** to **4.7.**

(2) A ship having been built with an insufficient number of transverse watertight bulkheads to satisfy this requirement may be exempted form the application of **Pars 1** and **2** and this requirement provided the ship fulfills the requirement in **SOLAS XII Reg. 9.** ⚓

Annex 7-6 Water Level Detection & Alarms and Drainage & Pumping Systems for Bulk Carriers and Single Hold Cargo Ships

I. Water level detection & alarms

1. General

(1) The plans containing details on installation, welding and electrical equipment of the water ingress alarm system specified in this Annex to be submitted to the Society for approval.
After installation on board, this system is to be tested and inspected by the attending Surveyor.

(2) Any water level detection & alarm is to be approved by the Society in accordance with the requirements of the relevant regulations.

(3) In order to avoid the inappropriate application of provisions of chapters II-1, III, IX, XI-1 and XII to certain dedicated ship types, the following cargoes are excluded from the scope of cargoes deemed, for the purpose of determining ship type, to be dry cargoes carried in bulk;
(A) woodchips; and
(B) cement, fly ash and sugar,
provided that loading and unloading is not carried out by grabs heavier than 10 tonnes, power shovels and other means which frequently damage cargo hold structures. *(2019)*

2. Definitions

(1) **Water level detector** means a system comprising sensors and indication devices that detect and warn of water ingress in cargo holds and other spaces as required in **Ch 3, 1403. 1** and **3** of the Rule.

(2) **Sensor** means a unit fitted at the location being monitored that activates a signal to identify the presence of water at the location in **Ch 3, 1403. 1** and **3** of the Rule

(3) **Pre-alarm level** means the lower level(0.5 m, single hold cargo ships : not less than 0.3 m) at which the sensor(s) in the cargo hold space will operate.

(4) **Main alarm level** means the higher level(0.15D and above, however not exceed the maximum 2 m, single hold cargo ships : not more than 0.15D) at which the sensor(s) in the cargo hold space will operate or the sole level in spaces other than cargo holds

(5) **Overriding device** means a device to make keeping the current function of an equipment, though a set alarm signal in it would be taken place.

(6) **Visual indication** means indication by activation of a light or other device that is visible to the human eye in all levels of light or dark at the location where it is situated.

(7) **Audible indication** means an audible signal that is detectable at the location where it is signalled.

(8) **Depth of ship** means the distance from bottom of cargo hold to hatch coaming. (See Fig **1**)

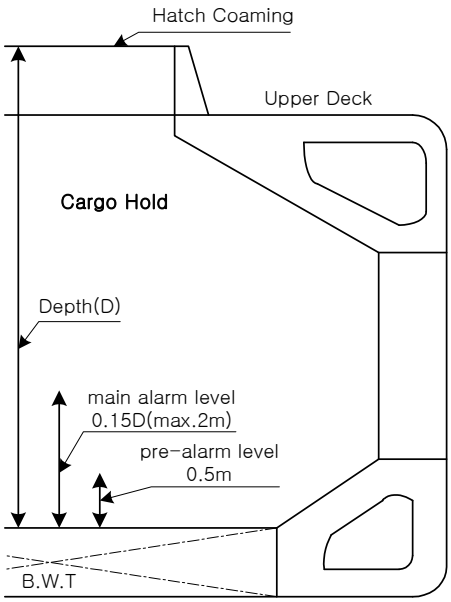


Fig 1 Depth of ship(D)

3. Installation requirements

(1) Bulk Carriers

(A) For cargo holds

(a) In each cargo hold, giving audible and visual alarms, one when the water level above the inner bottom in any hold reaches a height of 0.5 m and another at a height not less than 15% of the depth of the cargo hold but not more than 2 m. On bulk carriers to which **SOLAS Reg.XII/9.2** applies, detectors with only the latter alarm need be installed.

(b) The water level detectors are to be fitted in the aft end of the cargo hold. For cargo holds which are used for water ballast, an alarm overriding device may be installed. The visual alarms are to clearly discriminate between the two different water levels detected in each hold. The illustrations for application and location of installation are showing in **Fig 2** to **Fig 5.**

(c) The sensors may be installed inside of stools, where the ship has stools in cargo hold. In this case, the character of each sensor is to be considered in conjunction with installation.

(d) In case where the direct contact type detectors will be used, the inspection holes or the equivalent means are to be provided to remove the cargo/water mixture. The mesh size of filter element on inspection holes is to be decided by considering of the diameter of cargo particles and provided a spare filter element for each detector. Any filter element fitted to detectors is to be capable of being cleaned before new loading.

(B) In any ballast tank forward of the collision bulkhead required, giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10% of the tank capacity. An alarm overriding device may be installed to be activated when the tank is in use.

(C) In any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0.1 m above the deck. Such alarms need not be provided in enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume.

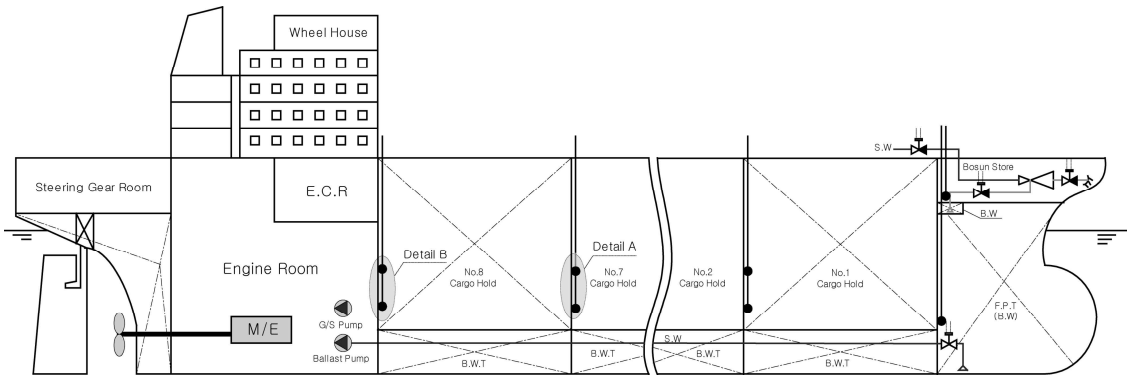


Fig 2 Installation position of water level detector

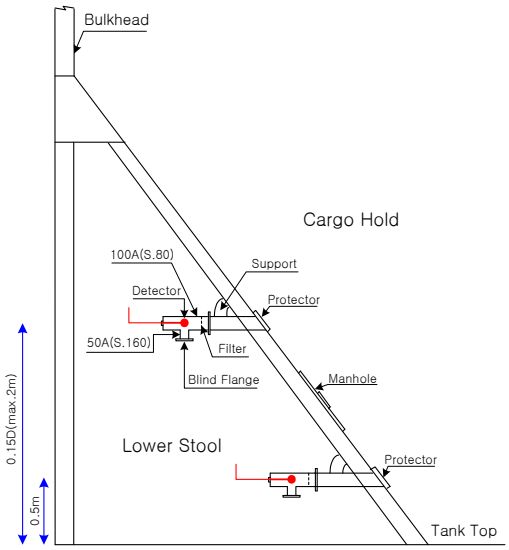


Fig 3 (Detail A)

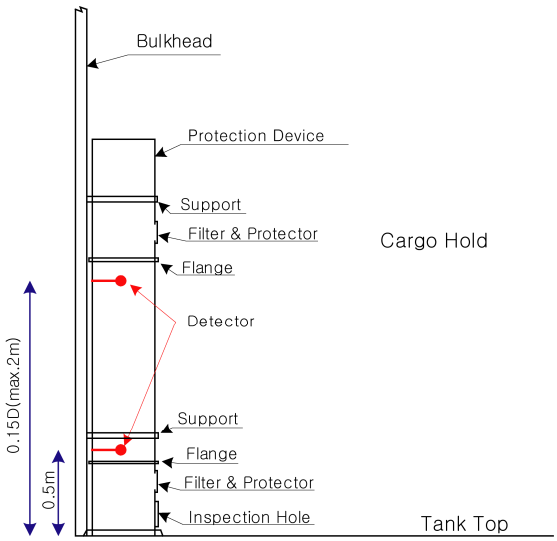


Fig 4 (Detail A)

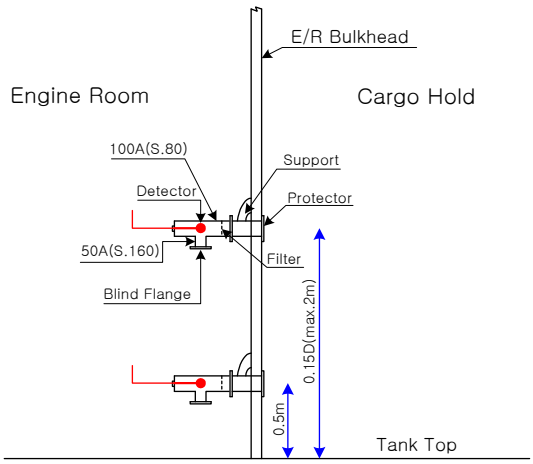


Fig 5 (Detail B)

(2) Single Hold Cargo Ships

(A) Those are to be fitted in such space with water level detectors which give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0.3 m, and another when such level reaches not more than 15 % of the mean depth of the cargo hold.

(B) Those are to be fitted at the aft end of the hold(above its lowest part where the inner bottom is not parallel to the designed waterline). Where webs or partial watertight bulkheads are fitted above the inner bottom, additional detectors are to be fitted.

4. Detector system requirements

(1) General

(A) This detecting system is to provide a reliable indication of water reaching a preset level. The audible and visual alarms are to be suitable for location on the navigation bridge. Here, one sensor capable of detecting both preset levels (pre-alarm level and main alarm level) is allowed.

(B) Protection of the enclosures of electrical components installed in cargo holds, ballast tanks and dry spaces are to be satisfied the requirements of **IP68** in accordance with **(KS C) IEC 60529.**

(C) Protection of the enclosures of electrical components installed above ballast and cargo spaces are to be satisfied the requirements of **IP56** in accordance with **(KS C) IEC 60529.**

(D) The water level detector system is to be capable of being supplied with electrical power from two independent electrical supplies as follows. Failure of the primary electrical power supply of them is to activate an alarm, both visual and audible.

(a) The electrical power supply is to be from two separate sources, one is to be the main source of electrical power and the other is to be the emergency source, unless a continuously charged dedicated accumulator battery is fitted, having arrangement, location and endurance equivalent to that of the emergency source (18h). The battery supply may be an internal battery in the water level detector system.

(b) The changeover arrangement of supply from one electrical source to another need not be integrated into the water level detector system.

(c) Where batteries are used for the secondary power supply, failure alarms for both power supplies are to be provided.

(2) For cargo holds

An alarm, both visual and audible, is to be activated each when the level of water reaches the pre-alarm level or main alarm level in the cargo hold being monitored. The visual alarm is to identify the cargo hold and the audible main alarm is not to be the same as that for the pre-alarm level.

(3) For compartments other than cargo holds

An alarm, both visual and audible, is to be activated when the level of water in the space being monitored is detected on sensor. The characteristics of the visual and audible alarm is to be the same as those for the main alarm level in a cargo hold.

5. Functional requirements

(1) Means of detecting water level

The method of detecting water level may be by direct or indirect means. A direct means determines the presence of water by physical contact of the water with detection device and indirect means of detection include devices such as the air purge or ultrasonic type sensor.

(2) Functional requirements

(A) The system of detecting water level is to be capable of continuous operation while the ship is at sea.

(B) Detection equipment is to be suitably corrosion resistant for all intended cargoes. Detection equipment includes the sensor, any filter and protection arrangements for the detector installed in cargo holds and other spaces as required by **Ch 3, 1403. 1** and **3** of the Rule.

(C) The detector indicating the water level is to be capable of activating to an accuracy of ±100 mm.

(D) The part of the system which has circuitry in the cargo area, is to be certified intrinsically safe type and at least a **IIB T3** in accordance with **(KS C) IEC** publication **60079.** Where a ship is designed only for the carriage of cargoes that cannot create a combustible or explosive atmosphere then the requirement for intrinsically safe circuitry is not to be insisted upon, provided the operational instructions included in the Manual specifically exclude the carriage of cargoes that could produce a potential explosive atmosphere. Any exclusion of cargoes is to be consistent with the ship's cargo book and any certification relating to the carriage of specifically identified cargoes.

The maximum surface temperature of equipment installed within cargo spaces is to be appropriate for the combustible dusts and explosive gasses likely to be encountered. Where the characteristics of the dust and gases are unknown, the maximum surface temperature of equipment is not to exceed 85 deg. C.

Where detector systems include intrinsically safe circuits, plans of the arrangements are to be submitted and approved.

(E) Detectors serving a cargo hold is to be capable of being functionally tested in situation when the hold is empty using either direct or indirect methods.

(3) Installation of sensors

(A) The sensors are to be located in a protected position that is communication with the aft part of the cargo hold such that position of the sensor detects the level that is representative of the levels in the actual hold space. These sensors are to be located either as close to the centerline as practicable, or at both the port and starboard sides of the cargo hold.

(B) The detector installation should not inhibit the use of any sounding pipe or other water level gauging device for cargo holds or other spaces and detectors and equipment are to be in-

stalled where they are accessible for survey, maintenance and repair.

(C) Electrical cables and any associated equipment installed in cargo holds are to be protected from damage by cargoes or mechanical handling equipment associated with bulk carrier operations, such as in tubes of robust construction or in similar protected locations.

6. Alarm system requirements

(1) The visual and audible alarms are to be suitable for location on the navigation bridge. These alarms are to be complied with the requirements of primary alarm in the **Code on Alerts and Indicators, 2009.** The pre-alarm, as a primary alarm, is to indicate a condition that requires prompt attention to prevent an emergency condition and the main alarm, as an emergency alarm, is to indicate that immediate actions are to be taken to prevent danger to human life or to the ship.

(2) Visual indication using a light of a distinct colour, or digital display that is clearly visible in all expected light levels, which does not seriously interfere with other activities necessary for the safe operation of the ship. The visual indication is to be capable of remaining visible until the condition activating it has returned below the level of the relevant sensor. The visual indication is not to be capable of being extinguished by the operator. In case of the system with a flickering function, that flicker is to be capable of being muted by the operator, but, at that time, the visual indication is not to be extinguished.

(3) In conjunction with the visual indication for the same sensor, the system is to be capable of providing audible indication and alarms in the space in which the indicator is situated. The audible indication is to be capable of being muted by the operator.

(4) Time delays may be incorporated into the alarm system to prevent spurious alarms due to sloshing effects associated with ship motions.

(5) The system may be provided with a capability of overriding indication and alarms for the detection systems installed only in tanks and holds that have been designed for carriage of water ballast. An override visual indication capability should be provided throughout deactivation of the water level detector for the holds or tanks. However, where such an override capability is provided, cancellation of the override condition and reactivation of the alarm should automatically occur after the hold or tank has been de-ballasted to a level below the lowest alarm indicator level.

(6) Notwithstanding the provisions of (5) above, The water ingress alarm system is not to be capable of overriding the alarm of the spaces (e.g., dry spaces, cargo holds, etc.), that are neither designed nor intended to carry water ballast.

(A) Enabling the facility to override alarms is to be customized for each specific ship prior to the commissioning tests witnessed by the Surveyor. In this case, the related drawings are to be submitted and approved before the work is commenced.

(B) A "Caution Plate", which prohibits personnel from overriding an alarm to any hold, is not an acceptable alternative to the above provisions.

(7) Alarms are to continuously monitor the system and activate a visual and audible alarm on detecting a fault. The audible alarm is to be capable of being muted by manual operation but the visual indication should remain active until the malfunction is cleared. The alarm for malfunction is distinguishable from the alarm for water level detecting, but it may be substituted the system fail alarm. Here, faults associated with the system means faults such as open circuit, short circuit, loss of power supplies and CPU failure, etc.

(8) Alarm systems are to be complied with the requirements of **(KS C)IEC 60092-504**. A test switch for visual indication and audible alarm is to be fitted on alarm panel and the switch is to be returned to the off position automatically after any use.

7. System test requirements

(1) Alarm system

(A) The visual indication is not to be extinguished by the operator.

(B) It is to be set at a level that alerts operators and tested, but does not interfere with the safe operation of the ship.

(C) That they are distinguishable from other alarms.

(2) Water level detectors

(A) After installation on board, a functionality test for detectors is to be carried out. The test is to be represented the presence of water at the detectors for every level monitored, but simulation methods may be used where the direct use of eater is impracticable.

(B) Each detector alarm should be tested to verify that the pre-alarm(0.5 m, single hold cargo ships : not less than 0.3 m) and main alarm levels[0.15 D (max. 2 m), single hold cargo ships : not more than 0.15 D] operate for every space where they are installed and indicate correctly. Also, the fault monitoring arrangements should be tested as far as practicable.

(C) Records of testing of alarm systems should be retained on board.

8. Manuals

Documented operating and maintenance procedures for water level detection containing the following informations are to be kept on board and readily accessible and the procedures are to be written in working language of the master and officers:

- A description of the equipment for detection and alarm arrangements
- Evidence that the equipment has been type tested
- Line diagrams of the detection and alarm system showing the positions of equipment.
- Installation instructions for setting, securing, protecting and testing.
- List of cargoes for which the detector is suitable for operating in a 50% seawater slurry mixture
- Procedures to be followed in the event of equipment not functioning correctly.
- Maintenance requirements for equipment and system.

II. Drainage and pumping syste

1. General

The plans containing piping diagram of drainage and pumping systems specified in this Annex are to be submitted for approval by the Society and after installation on board, a functionality test for the pumping system is to be carried out.

2. Position for installation

(1) Ballast tanks forward of the collision bulkhead

(2) Dry spaces other than chain lockers, any part of which extends forward of the foremost cargo hold and the volume of which exceeds 0.1% of the ship's maximum displacement volume.

3. Requirements for installation

(1) The means for draining and pumping ballast tanks forward of the collision bulkhead and bilges of dry spaces any part of which extends forward of the foremost cargo hold shall be capable of being brought into operation from a readily accessible enclosed space, the location of which accessible from the navigation bridge or propulsion machinery control position without traversing exposed freeboard or superstructure decks.

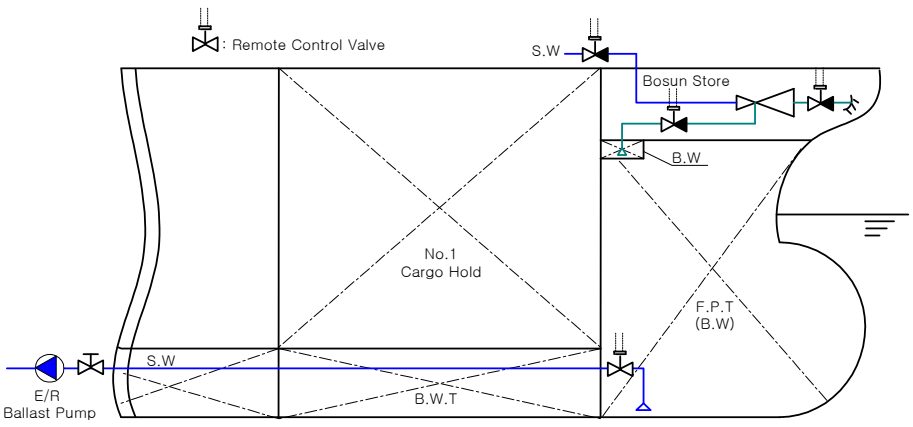


Fig 6 Application example

(2) Where the piping arrangements for dewatering closed dry spaces are connected to the piping arrangements for the drainage of water ballast tanks, two non-return valves are to be provided to prevent the ingress of water into dry spaces from those intended for the carriage of water

ballast. One of these non-return valves is to be fitted with shut-off isolation arrangement. The non-return valves are to be located in readily accessible positions. The shut-off isolation arrangement are to be capable of being controlled from the navigation bridge, the propulsion machinery control position or enclosed space which is readily accessible from the navigation bridge or the propulsion machinery control position without travelling exposed freeboard or superstructure decks. In this context, a position which is accessible via an under deck passage, a pipe trunk or other similar means of access is not to be taken as being in the "readily accessible enclosed space".

(3) Where pipes serving such tanks or bilges pierce the collision bulkhead, valve operation by means of remotely operated actuators may be accepted provided that the location of such valve controls complies with this regulation **3** (1).

(4) The remote control valve is not to move from the demanded position in the case of failure of the control system power or actuator power.

(5) Positive indication is to be provided at the remote control station to show that the valve is fully open or closed.

(6) The dewatering arrangements are to be such that when they are in operation, other systems essential for the safety of the ship including fire-fighting and bilge systems remain available and ready for immediate use. The systems for normal operation of electric power supplies, propulsion and steering are not to be affected by the operation of the dewatering systems.

(7) Bilge wells in dry space are to be provided with gratings or strainers that will prevent blockage of the dewatering system with debris.

(8) The enclosures of electrical equipment for the dewatering system installed in any of the forward dry spaces are to provide protection to IPX8 standard as defined in **Pt 6, Ch 1, 201. 1** (2) (A) (b) of the Guidance, **Table 6.1.3** and (KS C) (KS C) IEC Publication 60529 for a water head equal to the height of the space in which the electrical equipment is installed for a time duration of at least 24 hours.

(9) The dewatering system for ballast tanks located forward of the collision bulkhead and for bilges of dry spaces any part of which extends forward of the foremost cargo hold is to be such that any accumulated water can be drained directly by a pump or eductor and to be designed to remove water from the forward spaces at a rate of not less than the following formula.

$$Q = 320 \times A$$

where :

Q : Capacity of the dewatering system (m^3/h)

A : Cross-sectional area of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements (m^2) ⚓

Annex 7-7 Unified Interpretation of Convention

(Unless expressly specified otherwise, the requirements in these Annex apply in accordance with keeling date based on SOLAS Convention)

1. UI SC 207 (Structural Strength of Bulk Carriers in case of Accidental Hold Flooding) *(2020)*

(1) This is to clarify the implementation between SOLAS XII/5.2 and IACS UR S17, S18 and S20, these structural requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers of 150 m in length and above, intending to carry solid bulk cargoes 1.0 t/m^3 density or above.

(2) Unified Interpretation

Regardless of the date of contract for construction, or the cargo hold cross section configuration, of ships which shall comply with SOLAS XII/5.2, such ships are to comply with IACS Unified Requirements(UR) S17, S18 for corrugated transverse bulkheads, where fitted, and S20, if they do not comply with the IACS CSR for Bulk Carriers and Oil Tankers.

(3) This UI is to be applied to ships contracted for construction on or after 1 July 2015.

2. UI SC 208 (Protection of Cargo Holds Loading/Unloading Equipment) *(2020)*

(1) This is to clarify the implementation between SOLAS XII/6.4.1 (SLS. 14 / Circ. 250) and IACS CSR for Bulk Carriers and Oil Tankers, in terms of protection of cargo holds from loading/discharge equipment of bulk carriers of 150 m in length and above, intending to carry solid bulk cargoes 1.0 t/m^3 density or above.

(2) Unified Interpretation

Bulk carriers which shall comply with SOLAS regulation XII/6.4.1 and which do not comply with the IACS CSR for Bulk Carriers and Oil Tankers, are to comply with the following:

(A) The grab requirements of **Pt 3,** of the Rules.

(B) Wire rope grooving in way of cargo holds openings is to be prevented by fitting suitable protection such as half-round bar on the hatch side girders(i.e. upper portion of top side tank plates)/hatch end beams in cargo hold and upper portion of hatch coamings.

(3) The requirements of (A) and (B) are satisfied, "Grab" notation of our Society is to be imposed.

(4) This UI is to be applied to ships contracted for construction on or after 1 July 2015.

3. UI SC 209 (Failure of Cargo Hold Structural Members and Panels) *(2020)*

(1) This is to provide a standard for the transverse buckling of ordinary stiffeners for ships which shall comply with SOLAS XII/6.4.3, but are not designed according to CSR for Bulk Carriers and Oil Tankers.

(2) Unified Interpretation

Ships which shall comply with SOLAS XII/6.4.3 are to satisfy either (A) or (B) as given below.

(A) For ships subjected to CSR : **Pt 13 Sub-part 1 Ch 3, Sec 1** "Material" and **Pt 13 Sub-part 1 Ch 8, Sec 5 Ch 6, Sec 3** "Buckling Capacity".

(B) For ships not designed according to CSR (**Pt 13 Sub-part 1 Ch 3, Sec 1** and **Ch 8, Sec 5**):

(a) For ships with single side structures the material grade shall not be less than grade D/DH for :

- lower bracket of side frame
- side shell plate between two points located to 0.125 l above and 0.125 l below the intersection of side shell and bilge hopper sloping plate or inner bottom plate. The span of the side frame, l, is defined as the distance between the supporting structures.

  In case of side frames built with multiple spans, the above requirements apply to the lower part only. (See **Fig 1**)

(b) The safety factor with respect to lateral buckling of longitudinal and transverse ordinary stiffeners is to be increased by a factor at least 1.15(allowable utilization factor to be reduced by at least 1/1.15=0.87) for the following areas.

- hatchway coaming
- inner bottom

- sloped stiffened panel of topside tanks and hopper tanks (if any)
- inner side (if any)
- top stool and bottom stool of transverse bulkhead (if any)
- stiffened transverse bulkhead (if any)
- side shell (if directly bounding the cargo hold)
  The lateral buckling requirements of ordinary stiffeners shall be in accordance with the Rules of the Society.

(3) This UI is to be applied to ships contracted for construction on or after 1 July 2020.

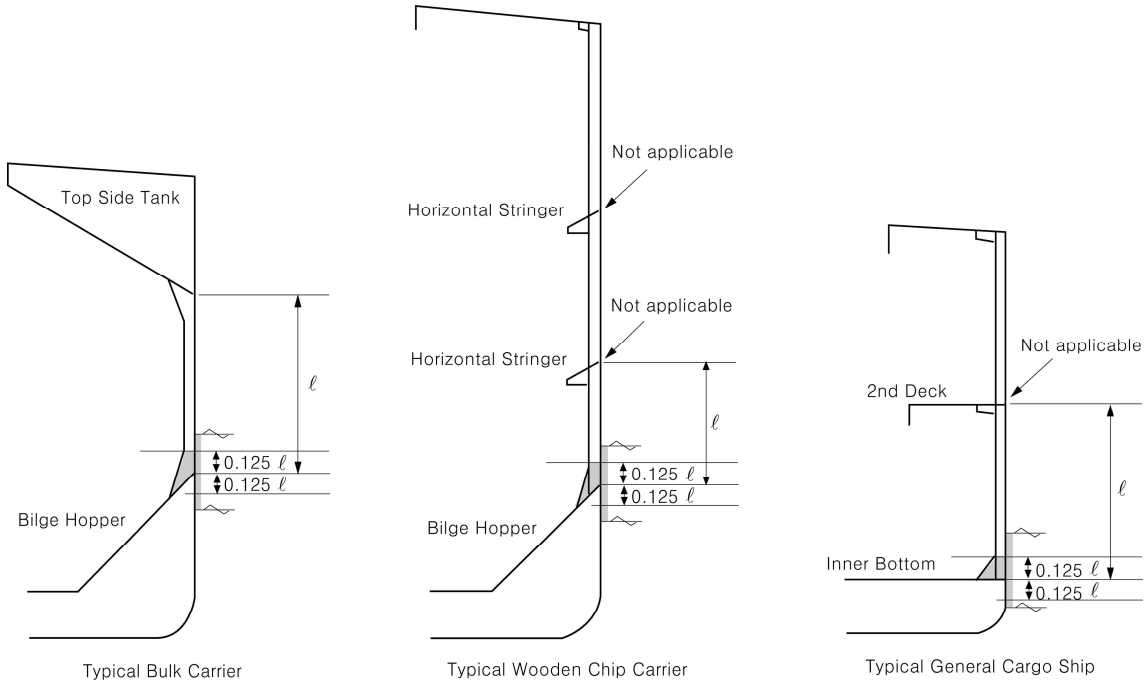


Fig 1 Typical configuration

Annex 7-8 Instruction for Use of Extremely Thick Steel in Container Ships *(2021)*

1. Application

(1) General

(A) This instruction is to be complied with for container ships incorporating extremely thick steel plates having steel grade and thickness in accordance with (2) and (3) respectively.

(B) This Instruction identifies when measures for prevention of brittle fracture of extremely thick steel plates are required for longitudinal structural menbers.

(C) This instruction gives the basic concepts for application of extremely thick steel plates to longitudinal structural members in the upper deck.

(D) This instruction defines the following methods to apply to the extremely thick plates of container ships for preventing the crack initiation and propagation:

a) Non-Destructive Testing(NDT) during construction detailed in **2**

b) Welding to increase toughness in **3**

c) Brittle crack arrest design detailed in **4**

The application of the measures specified in **2, 3** and **4** of this instruction is to be in accordance with **5**.

(E) For the application of this instruction, the upper deck region means the upper deck plating, hatch side coaming plating, hatch coaming top plating and their attached longitudinals.

(2) Steel Grade

(A) This instruction is to be applied to when any of YP36, YP40 and YP47 steel plates are used for the longitudinal structure members in the upper deck region.

(B) YP36 YP40 and YP47 means the steel plates having the minimum specified yield points of 355, 390 and 460 $\mathrm{N/mm^2}$, respectively.

(C) In case YP47 steel plates are used for longitudinal structural members in the upper deck region, the steel plates are to be EH47-H specified in **Pt 2, Ch 1, Sec 3.**

(3) Thickness

(A) For steel plates with thickness of over 50 mm and not greater than 100mm, the measures for prevention of brittle crack initiation and propagation specified in **2, 3** and **4** are to be taken.

(B) For steel plates with thickness exceeding 100 mm, appropriate measures for prevention of brittle crack initiation and propagation are to be taken in accordance with the Society's procedures.

2. Non-Destructive Testing (NDT) during construction (Measure No.1 of 5)

Where NDT during construction is required in **5**, the NDT is to be in accordance with (1) and (2). Enhanced NDT as specified in **4** (3) (E) is to be carried out in accordance with an appropriate standard.

(1) General

(A) Ultrasonic testing (UT) is to be carried out on all block-to-block butt joints of all upper flange longitudinal structural members in the cargo hold region.

(B) Upper flange longitudinal structural members include the topmost strakes of the inner hull/bulkhead, the sheer strake, main deck, coaming plate, coaming top plate, and all attached longitudinal stiffeners. These members are defined in **Fig 1**.

(C) Testing procedure of UT not specified in this Instruction are to comply with the requirements in **Pt 2, Annex 2-7 of the Guidance.**

(a) Scanning has to be performed from at least one surfaces and both sides of the welded seam as shown in **Fig 2**. (Scanning from root face is recommended.)

(b) Testing has to be performed with two probes 70° and 45° or 70° and 60° depending on the bevel preparation.

(c) Any possible differences in attenuation and surface character between the calibration block and the welded seam to be tested are to be checked in accordance with KS B 0896 or equivalent.

(d) In case where the detected echo signal is suspicious as vertically oriented defect such as lack of fusion(LF) based on the calculation of sound path, the length of the detected echo signal is to be measured by 6 dB drop method and evaluated regardless of echo height.(acceptance criteria : $\leq 25\ \mathrm{mm}$)

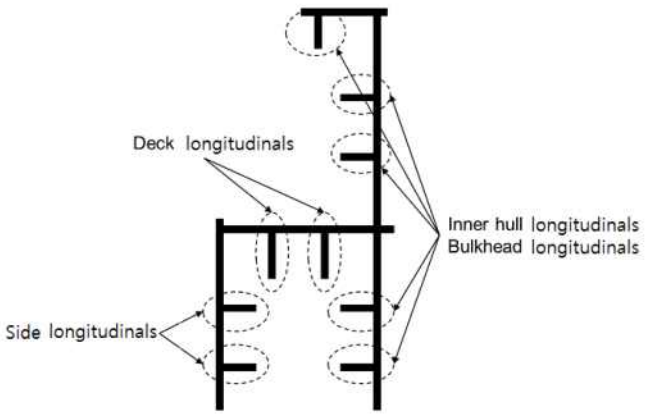


Fig 1 Upper Flange Longitudinal Structural Members

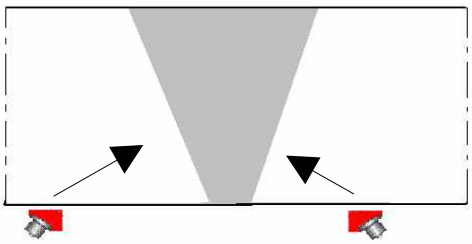


Fig 2 Scanning from root face and both sides

(e) For the NDE personnel engaged in UT of extremely thick steel plates welds, the shipyard should give education and training related to the detecting and evaluation of vertically oriented defect.

(f) In order to detect transverse defects, scanning to be made with an angle probe angled about 15 degree from weld axis on at least one surface and both sides or with an angle probe along the centre line of the weld as shown in **Fig 3**.

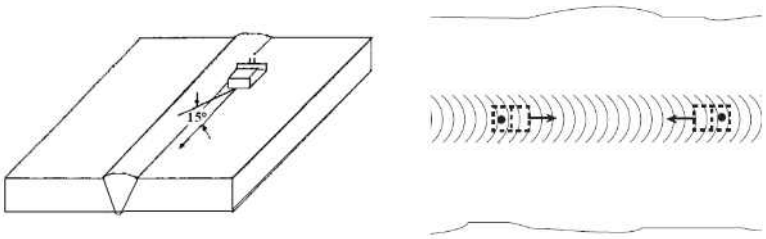


Fig 3 UT scanning examples for detecting the transverse defects

(2) Acceptance criteria of UT

(A) Acceptance criteria of UT not specified in this Instruction are to comply with the requirements in **Pt 2, Annex 2-7 of the Guidance.**

(B) The acceptance criteria may be adjusted under consideration of the appertaining brittle crack initiation prevention procedure and where this is more severe than that found in **Pt 2, Annex 2-7 of the Guidance,** the UT procedure is to be amended accordingly to a more severe sensitivity.

3. Welding to increase toughness(Measure No.2 of [5])

3.1 Welding to increase toughness is to be carried out when B option in [5] is selected as a safety measure to identify and prevent brittle fracture.

3.2 Impact specimens are to be taken in accordance with 3.2.1.

3.2.1 Impact specimens are to be taken from the weld center "WM", fusion line "FL", heat affected zone of 2mm from fusion line, heat affected zone of 5mm from fusion line.

3.3 Impact specimens are to meet the criteria for absorbed energy of base material at impact test temperature of base material.

4. Brittle crack arrest design (Measure No. 3, 4 and 5 of 5)

(1) General

(A) The brittle crack arrest steel method detailed in **4** may be used when the measures No. 3, 4, and 5 of 5 are applied and the steel grade material of the upper deck is not higher than YP40. Otherwise other means for preventing the crack initiation and propagation shall be agreed with the Society.

(B) Measures for prevention of brittle crack propagation are to be taken within the cargo hold region. A brittle crack arrest design means a design using these measures.

(C) The measures given in this section generally apply to the block-to-block joints but it should be noted that cracks can initiate and propagate away from such joints. Therefore, appropriate measures should also be considered for the cases specified in (2)(B)(b).

(D) Brittle crack arrest steels are defined in **Pt 2, Ch 1, Sec 3.**

(2) Functional requirements of brittle crack arrest design

The purpose of the brittle crack arrest design is aimed at arresting propagation of a crack at a proper position and to prevent large scale fracture of the hull girder.

(A) The locations of most concern fro brittle crack initiation and propagation are the block-to-block butt weld joints either on hatch side coaming or on upper deck plating. Other locations in block fabrication where joints are aligned may also present higher opportunity for crack initiation and propagation along butt weld joints.

(B) Both of the following cases are to be considered:

(a) where the brittle crack runs straight along the butt joint, and

(b) where the brittle crack initiates in the butt joint but deviates away from the weld and into the plate, or where the brittle crack initiates from any other weld and propagates into the plate.

(c) "Other weld" in (b) includes the following(refer to **Fig 4**):

1 Fillet weld between hatch side coaming plating, including top plating, and longitudinals;

2 Fillet weld between hatch side coaming plating, including top plating and longitudinals, and attachments. (e.g., Fillet welds between hatch side top plating and hatch cover pad plating.);

3 Fillet weld between hatch side coaming top plating and hatch side coaming plating;

4 Fillet weld between hatch side coaming plating and upper deck plating;

5 Fillet weld between upper deck plating and inner hull/bulkheads;

6 Fillet weld between upper deck plating and longitudinals; and

7 Fillet weld between sheer strakes and upper deck plating.

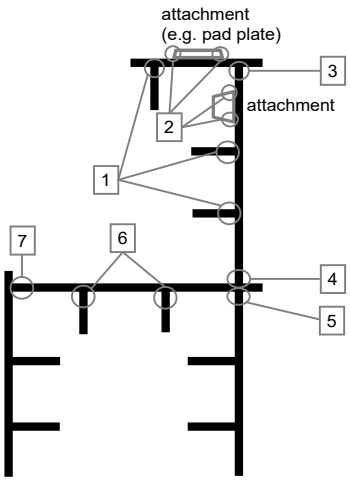


Fig 4 Other weld areas

(3) Concept examples of brittle crack arrest design
The followings are considered to be acceptable examples of measures that can be used on a brittle crack arrest-design to prevent brittle crack propagations. The detail design arrangements are to be submitted to the Society for their approval. Other measures may be considered and accepted for review by the Society.

(A) Brittle crack arrest design for (2) (B) (b):

(a) Brittle crack arresting steel is to be used for the upper deck along the cargo hold region in a way suitable to arrest a brittle crack initiating from the coaming and propagating into the structure below.

(B) Brittle crack arrest design for (2) (B) (a):

(a) Where the block to block butt welds of the hatch side coaming and those of the upper deck are shifted, this shift is to be greater than or equal to 300 mm. Brittle crack arrest steel is to be provided for the hatch side coaming.

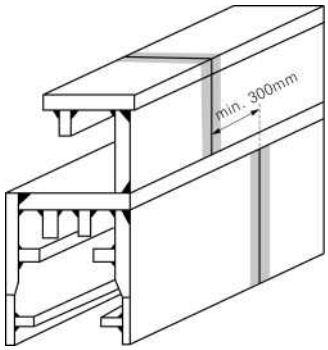
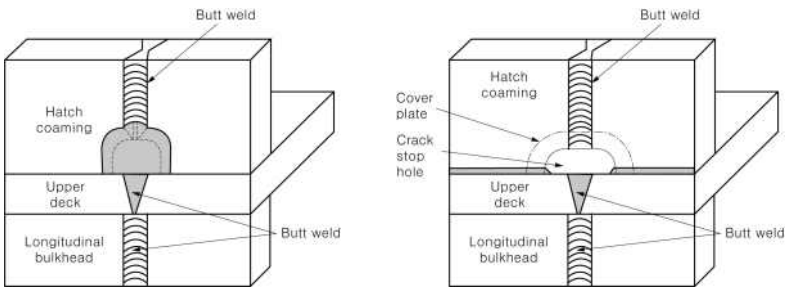


Fig 5 An example of block to block butt-shift

(C) Where crack arrest holes are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, the fatigue strength of the lower end of the butt weld is to be assessed. Additional countermeasures are to be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming. These countermeasures are to include the application of brittle crack arrest steel in hatch side coaming.



(a) Arrest welding type (b) Arrest hole type

Fig 6 An example of joint arrangement for arresting the brittle crack propagation

(D) Where Arrest Insert Plates of brittle crack arrest steel or Weld Metal Inserts with high crack arrest toughness properties are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, additional countermeasures are to be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming. These countermeasures are to include the application of brittle crack arrest steel in hatch side coamings.

(E) The application of enhanced NDT particularly time of flight diffraction (TOFD) technique using stricter defect acceptance in lieu of standard UT technique specified in **2** can be an alternative to (B), (C) and (D) above.

(4) Selection of brittle crack arrest steels
(A) The brittle crack arrest steels fitted in the upper deck region of container ships are to comply with Table 1 where suffixes BCA1 and BCA2 are defined in **Rule Part 2**.
(B) The brittle crack arrest steel property is to be selected for each individual structural member with thickness above 50mm according to Table 1.

Table 1 Brittle crack arrest steel requirement in function of structural members and thickness

Structural Members plating(1)	Thickness(mm)	Brittle crack arrest steel requirement
Upper deck	$50 < t \leq 100$	Steel grade YP36 or 40 with suffix BCA1
Hatch coaming side	$50 < t \leq 80$	Steel grade YP40 or 47 with suffix BCA1
	$80 < t \leq 100$	Steel grade YP40 or 47 with suffix BCA2
Note (1)Excluding their attached longitudinals		

(C) When brittle crack arrest steels as specified in Table 1 are used, the weld joints between the hatch coaming side and the upper deck are to be partial penetration weld details approved by the Society.
In the vicinity of ship block joints, alternative weld details may be used for the deck and hatch coaming side connection provided additional means for preventing the crack propagation are implemented and agreed by the Society in this connection area.

5. Measures for Extremely Thick Steel Plates

The thickness and the yield strength shown in the **Table 2** apply to the hatch coaming top plating and side plating, and are the controlling parameters for the application of countermeasures. These controlling parameters are not applicable for the upper deck.

If the as built thickness of the hatch coaming top plating and side plating is below the values contained in the table, countermeasures are not necessary regardless of the thickness and yield strength of the upper deck.

6. Application of YP47 Steel Plates

These requirements apply to YP47 steel plates specified in **Pt 2, Ch 1, 311.**.
(1) Hull structures (design)
(A) HT factor (Material factor of high tensile steel, K) for the assessment of hull girder strength is to be taken as 0.62.
(B) Fatigue assessment on the longitudinal structural members is to be performed in accordance with **Pt 3, Annex 3-3**. In addition to the structural members of container carriers for the fatigue strength assessment specified in **Pt 3, Annex 3-3, Table 6**, butt welds in the hatch side coaming and fillet welded joints for fixing outfitting items, etc. are to be included in the locations for the fatigue strength assessment.
(C) Butt welds in the hatch side coaming and fillet welded joints for fixing outfitting items are to be set at an adequate distance from the hatch corners so that effects of stress concentration are to be avoided.
(D) The free edge including hatch corner of the hatch side coaming should not have any defects such as notch that could be harmful against fatigue strength. Appropriate edge treatment including treatment of corner edge (as an example, see **Fig 7**) is to be performed so that the edges should have adequate fatigue strength.
(E) In case of fitting of outfitting items such as hatch cover pads and container pads, taper is to be provided on the edge of the outfitting item so that a very large difference in rigidity does not occur between outfitting items and the hull structure. Measures such as increasing the thickness of plating at the fitted location are also to be adopted.
(F) Special consideration is to be paid to the construction details where extremely thick steel plates are applied as structural members such as connections between outfitting and hull structures.

Table 2 Measures for extremely thick steel plates

Yield Strength (kgf/mm^2)	Thickness (mm)	Option	Measures			
			1	2	3+4	5
36	50<t≤85	-	N.A.	N.A.	N.A.	N.A.
	85<t≤100	-	O	N.A.	N.A.	N.A.
40	50<t≤85	-	O	N.A.	N.A.	N.A.
	85<t≤100	A	O	N.A.	O	O
		B	O*	O**	N.A.	O
47 (FCAW)	50<t≤100	A	O	N.A.	O	O
		B	O*	O**	N.A.	O
47 (EGW)	50<t≤100	-	O	N.A.	O	O

Measures:

No.	Measures
1	NDT other than visual inspection on all target block joints (during construction) **2**.
2	Welding to increase toughness(during construction) See **3**.
3	Brittle crack arrest design against straight propagation of brittle crack along weld line to be taken (during construction) See **4** (3) (B), (C) or (D) of this Instruction.
4	Brittle crack arrest design against deviation of brittle crack from weldline (during construction) See **4** (3) (A).
5	Brittle crack arrest design against propagation of cracks from other weld such as fillets and attachment welds. (during construction) See **4** (3) (A).

Symbols:
(a) "O" means "To be applied".
(b) "N.A." means "Need not to be applied".
(c) Selectable from option "A" and "B".

Note:
* : See 4 (3) (E)
** : See 3.

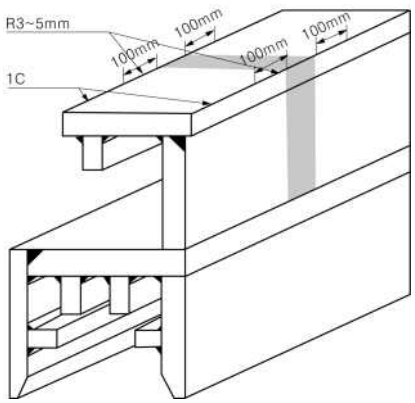


Fig 7 An example of appropriate edge treatment including corner edge

Annex 7-9 Guidance for the Longitudinal Strength of Container Ships

The requirements of this Annex are to be used for calculation of shear flow, buckling capacity and hull girder ultimate bending capacity of container ships.

Appendix 1 - Calculation of shear flow

1. General

(1) This annex describes the procedures of direct calculation of shear flow around a ship's cross section due to hull girder vertical shear force.

(2) The shear flow q_V at each location in the cross section, is calculated by considering the cross section is subjected to a unit vertical shear force of $1\mathrm{N}$.

(3) The unit shear flow per mm, $q_V\,(\mathrm{N/mm})$ is to be taken as:

$$q_V = q_D + q_1$$

where:

q_D : Determinate shear flow, as defined in **2.**

q_1 : Indeterminate shear flow which circulates around the closed cells, as defined in **3.**

(4) In the calculation of the unit shear flow, q_V, the longitudinal stiffeners are to be taken into account.

2. Determinate shear flow

(1) The determinate shear flow, $q_D\,(\mathrm{N/mm})$ at each location in the cross section is to be obtained from the following line integration

$$q_D(S) = -\frac{1}{10^6 I_{y-net}} \int_0^s (z - z_n) t_{net} ds$$

where:

s : Coordinate value of running coordinate along the cross section (m)

I_{y-net} : Net moment of inertia of the cross section (m^4)

t_{net} : Net thickness of plating (mm)

z_n : Z coordinate of horizontal neutral axis from baseline (m)=

(2) It is assumed that the cross section is composed of line segments as shown in **Fig A1.1:** where each line segment has a constant plate net thickness. The determinate shear flow is obtained by the following equation.

$$q_{Dk} = -\frac{t\ell}{2 \times 10^6 I_{y-net}} (z_k + z_i - 2z_n) + q_{Di}$$

where:

q_{Dk}, q_{Di} : Determinate shear flow at node k and node i respectively $(\mathrm{N/mm})$

ℓ : Length of line segments (m)

y_k, y_i : Y coordinate of the end points k and i of line segment (m), as defined in **Fig A1.1**

z_k, z_i : Z coordinate of the end points k and i of line segment (m), as defined in **Fig A1.1**

(3) Where the cross section includes closed cells, the closed cells are to be cut with virtual slits, as shown in **Fig A1.2:** in order to obtain the determinate shear flow. These virtual slits must not be located in walls which form part of another closed cell.

(4) Determinate shear flow at bifurcation points is to be calculated by water flow calculations, or similar, as shown in **Fig A1.2**.

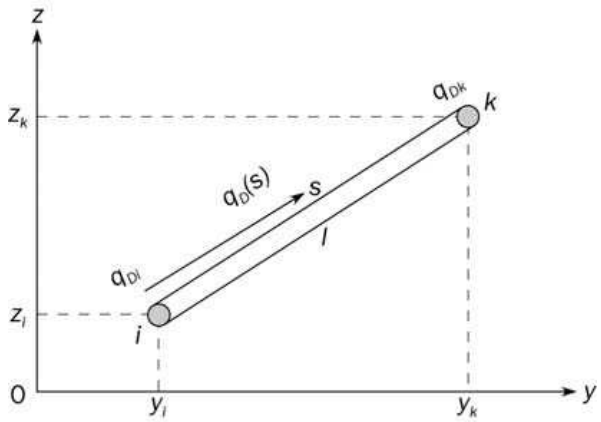


Fig A1.1 Definition of line segment

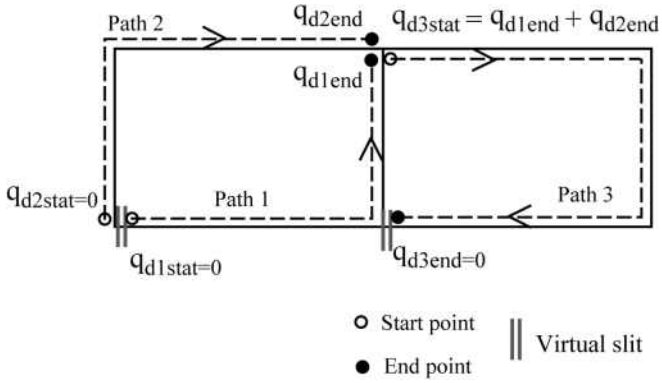


Fig A1.2 Placement of virtual slits and calculation of determinate shear flow at bifurcation points

3. Indeterminate shear flow

(1) The indeterminate shear flow around closed cells of a cross section is considered as a constant value within the same closed cell. The following system of equation for determination of indeterminate shear flows can be developed. In the equations, contour integrations of several parameters around all closed cells are performed.

$$q_{Ic} \oint_c \frac{1}{t_{net}} ds - \sum_{m=1}^{Nw} (q_{Im} \oint_{cm} \frac{1}{t_{net}} ds) = - \oint_c \frac{q_D}{t_{net}} ds$$

where:

Nw : Number of common walls shared by cell c and all other cells

c,m : Common wall shared by cells c and m

q_{Ic}, q_{Im} : Indeterminate shear flow around the closed cell c and m respectively $(\mathrm{N/mm})$

(2) Under the assumption of the assembly of line segments shown in **Fig A1.1** and constant plate thickness of each line segment, the above equation can be expressed as follows:

$$q_{Ic}\sum_{j=1}^{Nc}\left(\frac{\ell}{t_{net}}\right)_j-\sum_{m=1}^{Nw}\left\{q_{Im}\left[\sum_{j=1}^{Nm}\left(\frac{l}{t_{net}}\right)_j\right]_m\right\}=-\sum_{j=1}^{Nc}\phi$$

$$\phi=\left[-\frac{\ell^2}{6\times10^3 l_{y-net}}(Z_k+2Z_i-3Z_n)+\frac{\ell}{t_{net}}q_{Di}\right]_j$$

where:

Nc : Number of line segments in cell c

Nm : Number of line segments on the common wall shared by cells c and m

q_{Di} : Determinate shear flow $(\mathrm{N/mm})$ calculated according to **Appendix 1, 2**

(3) The difference in the directions of running coordinates specified in **Appendix 1, 2** and in this section has to be considered

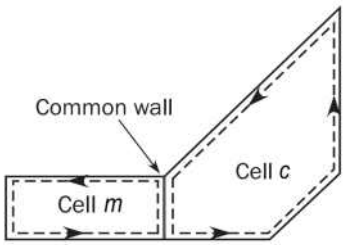


Fig A1.3 Closed cells and common wall

4. Computation of sectional properties

(1) Properties of the cross section are to be obtained by the following formulae where the cross section is assumed as the assembly of line segments.

$$\ell=\sqrt{(y_k-y_i)^2+(z_k-z_i)^2}$$

$$a_{net}=10^{-3}\ell\, t_{net} \qquad A_{n50}=\sum a_{net}$$

$$s_{y-net}=\frac{a_{net}}{2}(z_k+z_i) \qquad s_{y-net}=\sum s_{y-net}$$

$$i_{y0-net}=\frac{a_{net}}{3}(z_k^2+z_kz_i+z_i^2) \qquad I_{y0-net}=\sum i_{y0-net}$$

where:

a_{net}, A_{net} : Area of the line segment and the cross section respectively (m^2)

s_{y-net}, S_{y-net} : First moment of the line segment and the cross section about the baseline (m^3)

i_{y0-net}, I_{y0-net} : Moment of inertia of the line segment and the cross section about the baseline (m^4)

(2) The height of horizontal neutral axis z_m is to be obtained as follows:

$$z_m = \frac{s_{y-net}}{A_{net}} \quad (\mathrm{m})$$

(3) Inertia moment about the horizontal neutral axis I_{y-net} is to be obtained as follows:

$$I_{y-net} = I_{y0-net} - z_n^2 A_{net} \quad (\mathrm{m}^4)$$

Appendix 2 - Buckling Capacity 【See Rule】

Symbols

x_{axis} : Local axis of a rectangular buckling panel parallel to its long edge

y_{axis} : Local axis of a rectangular buckling panel perpendicular to its long edge

σ_x : Membrane stress applied in x direction $(\mathrm{N/mm^2})$

σ_y : Membrane stress applied in y direction $(\mathrm{N/mm^2})$

τ : Membrane shear stress applied in xy plane $(\mathrm{N/mm^2})$

σ_a : Axial stress in the stiffener $(\mathrm{N/mm^2})$

σ_b : Bending stress in the stiffener $(\mathrm{N/mm^2})$

σ_w : Warping stress in the stiffener $(\mathrm{N/mm^2})$

σ_1, σ_2, τ_c : Critical stress defined in **2.1.1** $(\mathrm{N/mm^2})$

R_{eH_S} : Specified minimum yield stress of the stiffener $(\mathrm{N/mm^2})$

R_{eH_P} : Specified minimum yield stress of the plate $(\mathrm{N/mm^2})$

a : Length of the longer side of the plate panel as shown in **Table 2** (mm)

b : Length of the shorter side of the plate panel as shown in **Table 2** (mm)

d : Length of the side parallel to the axis of the cylinder corresponding to the curved plate panel as shown in **Table 3** (mm)

σ_E : Elastic buckling reference stress $(\mathrm{N/mm^2})$

- For the application of plate limit state according to **2.1.2** :

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

- For the application of curved plate panels according to **2.2** :

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

ν : Poisson's ratio to be taken equal to 0.3

t_p : Net thickness of plate panel (mm)

t_w : Net stiffener web thickness (mm)

t_f : Net flange thickness (mm)

b_f : Breadth of the stiffener flange (mm)

h_w : Stiffener web height (mm)

e_f : Distance (mm) from attached plating to centre of flange to be taken as

$e_f = h_w$, for flat bar profile.

$e_f = h_w - 0.5\,t_f$, for bulb profile

$e_f = h_w + 0.5\,t_f$, for angle and Tee profiles

α : Aspect ratio of the plate panel, to be taken as $\alpha = a/b$

β : Coefficient taken as $\beta = \dfrac{1-\psi}{\alpha}$

ψ : Edge stress ratio to be taken as $\psi = \dfrac{\sigma_2}{\sigma_1}$

σ_1 : Maximum stress $(\mathrm{N/mm^2})$

σ_2 : Minimum stress $(\mathrm{N/mm^2})$

R : Radius of curved plate panel (mm)

ℓ : Span of stiffener equal to the spacing between primary supporting members (mm)

s : Spacing of stiffener to be taken as the mean spacing between the stiffeners of the considered stiffened panel (mm)

1. Elementary Plate Panel (EPP)

1.1 Definition

An Elementary Plate Panel (EPP) is the unstiffened part of the plating between stiffeners and/or primary supporting members. All the edges of the elementary plate panel are forced to remain straight (but free to move in the in-plane directions) due to the surrounding structure/neighbouring plates (usually longitudinal stiffened panels in deck, bottom and inner-bottom plating, shell and longitudinal bulkheads).

1.2 EPP with different thicknesses

1.2.1 Longitudinally stiffened EPP with different thicknesses

In longitudinal stiffening arrangement, when the plate thickness varies over the width, b (mm) of a plate panel, the buckling capacity is calculated on an equivalent plate panel width, having a thickness equal to the smaller plate thickness, t_1. The width of this equivalent plate panel, b_{eq} is defined by the following formula:

$$b_{eq} = \ell_1 + \ell_2 \left(\frac{t_1}{t_2} \right)^{1.5} \quad \text{(mm)}$$

where:

ℓ_1 : Width of the part of the plate panel with the smaller plate thickness, t_1 (mm) as defined in **Fig A2.1**

ℓ_2 : Width of the part of the plate panel with the greater plate thickness, t_2, (mm) as defined in **Fig A2.1**

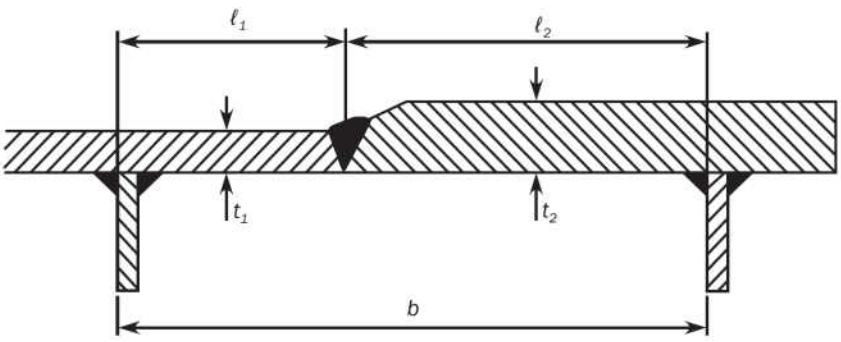


Fig A2.1 Plate thickness change over the width

1.2.2 Transversally stiffened EPP with different thicknesses

In transverse stiffening arrangement, when an EPP is made of different thicknesses, the buckling check of the plate and stiffeners is to be made for each thickness considered constant on the EPP.

2. Buckling capacity of plates

2.1 Plate panel

2.1.1 Plate limit state

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

a) Longitudinal stiffening arrangement:

$$\left(\frac{\gamma_c \sigma_x}{\sigma_{cx}}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_c |\tau|}{\tau_c}\right)^{2/\beta_p^{0.25}} = 1$$

b) Transverse stiffening arrangement

$$\left(\frac{\gamma_c \sigma_y}{\sigma_{cy}}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_c |\tau|}{\tau_c}\right)^{2/\beta_p^{0.25}} = 1$$

where:

σ_x, σ_y : Applied normal stress to the plate panel ($\mathrm{N/mm^2}$) as defined in **4.4** at load calculation points of the considered elementary plate panel

τ : Applied shear stress to the plate panel ($\mathrm{N/mm^2}$) as defined in **4.4** at load calculation points of the considered elementary plate panel

σ_{cx} : Ultimate buckling stress ($\mathrm{N/mm^2}$) in direction parallel to the longer edge of the buckling panel as defined in **2.1.3**

σ_{cy} : Ultimate buckling stress ($\mathrm{N/mm^2}$) in direction parallel to the shorter edge of the buckling panel as defined in **2.1.3**

τ_c : Ultimate buckling shear stress ($\mathrm{N/mm^2}$) as defined in **2.1.3**

β_p : Plate slenderness parameter taken as:

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

2.1.2 Reference degree of slenderness

The reference degree of slenderness is to be taken as:

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K\sigma_E}}$$

where:

K : Buckling factor, as defined in **Table 2** and **Table 3**.

2.1.3 Ultimate buckling stresses

The ultimate buckling stress of plate panels ($\mathrm{N/mm^2}$) is to be taken as:

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

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

The ultimate buckling stress of plate panels subject to shear ($\mathrm{N/mm^2}$) is to be taken as:

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

where:

C_x, C_y, C_τ : Reduction factors, as defined in **Table 2**

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

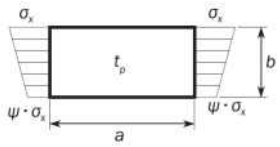
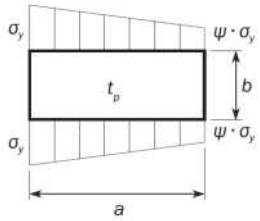
2.1.4 Correction Factor, F_{long}

The correction factor, F_{long} depending on the edge stiffener types on the longer side of the buckling panel is defined in **Table 1**. An average value of F_{long} is to be used for plate panels having different edge stiffeners. For stiffener types other than those mentioned in **Table 1**, the value of c is to be agreed by the Society. In such a case, value of c higher than those mentioned in **Table 1** can be used, provided it is verified by buckling strength check of panel using non-linear FE analysis and deemed appropriate by the Society

Table 1 Correction Factor (F_{long})

<table>
<tr><th colspan="3">Structural element types</th><th>F_{long}</th><th>c</th></tr>
<tr><td colspan="3">Unstiffened Panel</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="6">Stiffened Panel</td><td colspan="2">Stiffener not fixed at both ends</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="4">Stiffener fixed at both ends</td><td>Flat bar (1)</td><td rowspan="4">$F_{long} = c + 1$ for $\frac{t_w}{t_p} > 1$
$F_{long} = c(\frac{t_w}{t_p})^3 + 1$ for $\frac{t_w}{t_p} \le 1$</td><td>0.10</td></tr>
<tr><td>Bulb profile</td><td>0.30</td></tr>
<tr><td>Angle profile</td><td>0.40</td></tr>
<tr><td>T profile</td><td>0.30</td></tr>
<tr><td>Girder of high rigidity (e.g. bottom transverse)</td><td>1.4</td><td>N/A</td></tr>
<tr><td colspan="5">(1) t_w is the net web thickness (mm) without the correction defined in **4.3.5**</td></tr>
</table>

Table 2 Buckling Factor and reduction factor for plane plate panels

<table>
<tr><th>Case</th><th>Stress ratio (ψ)</th><th>Aspect ratio (α)</th><th>Buckling factor (K)</th><th>Reduction factor (C)</th></tr>
<tr><td rowspan="3">1
 
</td><td>$1 \geq \psi \geq 0$</td><td colspan="2">$K_x = F_{long}\dfrac{8.4}{\psi + 1.1}$</td><td rowspan="3">$C_x = 1,$ for $\lambda \leq \lambda_c$
$C_x = c\left(\dfrac{1}{\lambda} - \dfrac{0.22}{\lambda^2}\right),$ for $\lambda > \lambda_c$
where:
$c = (1.25 - 0.12\psi) \leq 1.25$
$\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$</td></tr>
<tr><td>$0 > \psi > -1$</td><td colspan="2">$K_x = F_{long}[7.63 - \psi(6.26 - 10\psi)]$</td></tr>
<tr><td>$\psi \leq -1$</td><td colspan="2">$K_x = F_{long}[5.975(1-\psi)^2]$</td></tr>
<tr><td rowspan="3">2
 

(continued)</td><td rowspan="3">$1 \geq \psi \geq 0$</td><td colspan="2">$K_y = \dfrac{2\left(1 + \dfrac{1}{\alpha^2}\right)^2}{1 + \psi + \dfrac{(1-\psi)}{100}\left(\dfrac{2.4}{\alpha^2} + 6.9 f_1\right)}$</td><td rowspan="3"></td></tr>
<tr><td>$\alpha \leq 6$</td><td>$f_1 = (1-\psi)(\alpha - 1)$</td></tr>
<tr><td>$\alpha > 6$</td><td>$f_1 = 0.6\left(1 - \dfrac{6\psi}{\alpha}\right)\left(\alpha + \dfrac{14}{\alpha}\right),$
But not greater than $14.5 - \dfrac{0.35}{\alpha^2}$</td></tr>
</table>

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

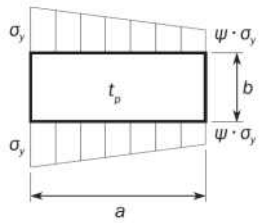
<table>
<tr><th>Case</th><th>Stress ratio (ψ)</th><th>Aspect ratio (α)</th><th>Buckling factor (K)</th><th>Reduction factor (C)</th></tr>
<tr><td rowspan="5">2.
 
</td><td rowspan="5">$0 > \psi \geq 1-\frac{4\alpha}{3}$</td><td colspan="2">$K_y = \frac{200\,(1+\beta^2)^2}{(1-f_3)\,(100+2.4\beta^2+6.9f_1+23f_2)}$</td><td rowspan="5">$C_y = c\left(\frac{1}{\lambda} - \frac{R+F^2(H-R)}{\lambda^2}\right)$
where:
$c = (1.25-0.12\psi) \leq 1.25$
$R = \lambda(1-\lambda/c)$, for $\lambda < \lambda_c$
$R = 0.22$, for $\lambda \geq \lambda_c$
$\lambda_c = 0.5c\left(1+\sqrt{1-0.88/c}\right)$
$F = \left[1-\left(\frac{K}{0.91}-1\right)/\lambda_p^2\right]c_1 \geq 0$
$\lambda_p^2 = \lambda^2-0.5$, $1 \leq \lambda_p^2 \leq 3$
$c_1 = \left(1-\frac{1}{\alpha}\right) \geq 0$
$H = \lambda - \frac{2\lambda}{c\left(T+\sqrt{T^2-4}\right)} \geq R$
$T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$</td></tr>
<tr><td>$\alpha > 6(1-\psi)$</td><td>$f_1 = 0.6\left(\frac{1}{\beta}+14\beta\right)$,
But not greater than $14.5-0.35\beta^2$
$f_2 = f_3 = 0$</td></tr>
<tr><td>$3(1-\psi) \leq \alpha \leq 6(1-\psi)$</td><td>$f_1 = \frac{1}{\beta} - 1$
$f_2 = f_3 = 0$</td></tr>
<tr><td>$1.5(1-\psi) \leq \alpha < 3(1-\psi)$</td><td>$f_1 = \frac{1}{\beta} - (2-w\beta)^4 - 9(w\beta-1)\left(\frac{2}{3}-\beta\right)$
$f_2 = f_3 = 0$</td></tr>
<tr><td>$1-\psi \leq \alpha < 1.5(1-\psi)$</td><td>• For $\alpha > 1.5$:
$f_1 = 2\left(\frac{1}{\beta} - 16\left(1-\frac{\omega}{3}\right)^4\right)\left(\frac{1}{\beta}-1\right)$
$f_2 = 3\beta - 2$
$f_3 = 0$
• For $\alpha \leq 1.5$:
$f_1 = 2\left(\frac{1.5}{1-\psi}-1\right)\left(\frac{1}{\beta}-1\right)$
$f_2 = \frac{\psi(1-16f_4^2)}{1-\alpha}$
$f_3 = 0$
$f_4 = (1.5-\mathrm{Min}(1.5;\alpha))^2$</td></tr>
</table>

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

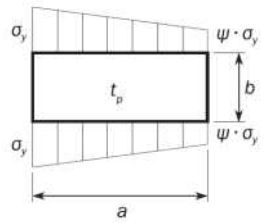
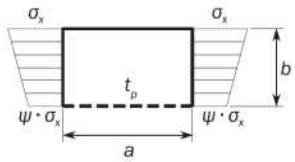
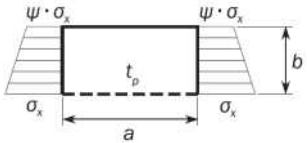
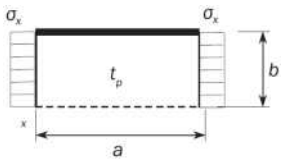
Case	Stress ratio (ψ)	Aspect ratio (α)	Buckling factor (K)	Reduction factor (C)
2. 	$0 > \psi \geq 1-\frac{4\alpha}{3}$	$0.75(1-\psi) \leq \alpha < 1-\psi$	$f_1 = 0$ $f_2 = 1+2.31(\beta-1)-48(4/3-\beta)f_4^2$ $f_3 = 3f_4(\beta-1)\left(\frac{f_4}{1.81}-\frac{\alpha-1}{1.31}\right)$ $f_4 = (1.5-\mathrm{Min}(1.5;\alpha))^2$	
	$\psi < 1-\frac{4\alpha}{3}$	$K_y = 5.972\frac{\beta^2}{1-f_3}$ where: $f_3 = f_5\left(\frac{f_5}{1.81}+\frac{1+3\psi}{5.24}\right)$ $f_5 = \frac{9}{16}(1+\mathrm{Max}(-1;\psi))^2$		
3 	$1 \geq \psi \geq 0$	$K_x = \frac{4(0.425+1/\alpha^2)}{3\psi+1}$		$C_x = 1$, for $\lambda \leq 0.7$ $C_x = \frac{1}{\lambda^2+0.51}$, for $\lambda > 0.7$
	$0 > \psi \geq -1$	$K_x = 4(0.425+1/\alpha^2)(1+\psi)-5\psi(1-3.42\psi)$		
4 	$1 \geq \psi \geq -1$	$K_x = \left(0.425+\frac{1}{\alpha^2}\right)\frac{3-\psi}{2}$		
5 	–	$\alpha \geq 1.64$	$K_x = 1.28$	
		$0 < \alpha < 1.64$	$K_x = \frac{1}{\alpha^2}+0.56+0.13\alpha^2$	

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

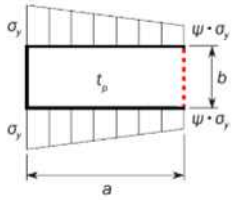
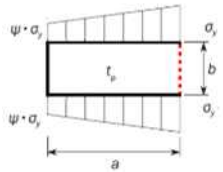
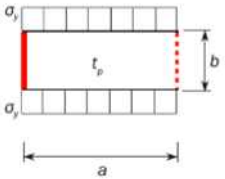
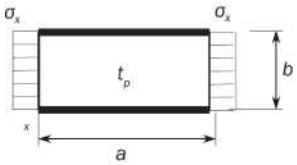
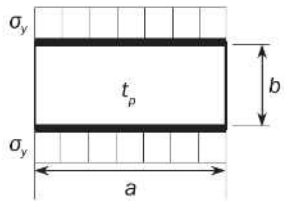
Case	Stress ratio (ψ)	Aspect ratio (α)	Buckling factor (K)	Reduction factor (C)
6. 	$1 \geq \psi \geq 0$	$K_y = \frac{4(0.425+\alpha^2)}{(3\psi+1)\alpha^2}$		$C_y = 1$ for $\lambda \leq 0.7$ $C_y = \frac{1}{\lambda^2+0.51}$ for $\lambda > 0.7$
	$0 > \psi \geq -1$		$K_y = 4(0.425+\alpha^2)(1+\psi)\frac{1}{\alpha^2} - 5\psi(1-3.42\psi)\frac{1}{\alpha^2}$	
7. 	$1 \geq \psi \geq -1$		$K_y = (0.425+\alpha^2)\frac{(3-\psi)}{2\alpha^2}$	
8. 	-		$K_y = 1 + \frac{0.56}{\alpha^2} + \frac{0.13}{\alpha^4}$	
9 	-		$K_x = 6.97$	$C_x = 1$ for $\lambda \leq 0.83$ $C_x = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$
10. 	-		$K_y = 4 + \frac{2.07}{\alpha^2} + \frac{0.67}{\alpha^4}$	

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

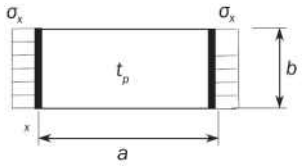
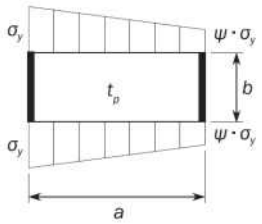
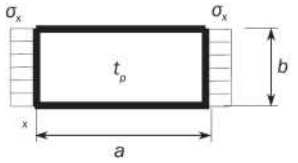
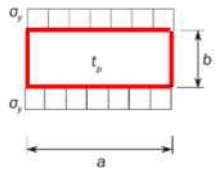
Case	Stress ratio (ψ)	Aspect ratio (α)	Buckling factor (K)	Reduction factor (C)
11 	-	$\alpha \geq 4$	$K_x = 4$	$C_x = 1$ for $\lambda \leq 0.83$ $C_x = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$
		$\alpha < 4$	$K_x = 4 + 2.74\left[\frac{4-\alpha}{3}\right]^4$	
12. 	-	$K_y = K_y$ determined as per case 2		$C_y = C_{y2}$ for $\alpha < 2$ $C_y = \left(1.06 + \frac{1}{10\alpha}\right)C_{y2}$ for $\alpha \geq 2$ $C_{y2} = C_y$ determined as per case 2
13. 	-	$\alpha \geq 4$	$K_x = 6.97$	$C_x = 1$ for $\lambda \leq 0.83$ $C_x = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$
		$\alpha < 4$	$K_x = 6.97 + 3.1\left[\frac{4-\alpha}{3}\right]^4$	
14. 	-	$K_y = \frac{6.97}{\alpha^2} + \frac{3.1}{\alpha^2}\left(\frac{4-1/\alpha}{3}\right)^4$		$C_y = 1$ for $\lambda \leq 0.83$ $C_y = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

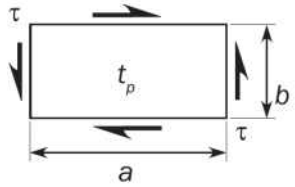
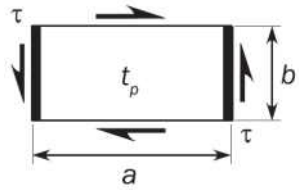
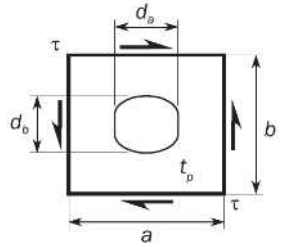
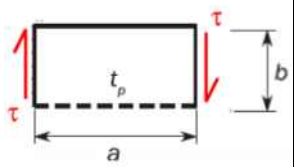
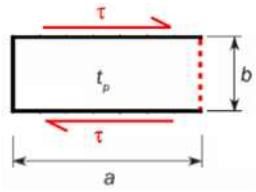
Case	Stress ratio (ψ)	Aspect ratio (α)	Buckling factor (K)	Reduction factor (C)
15 	-		$K_\tau = \sqrt{3}\left[5.34 + \frac{4}{\alpha^2}\right]$	$C_\tau = 1$, for $\lambda \le 0.84$ $C_\tau = \frac{0.84}{\lambda}$, for $\lambda > 0.84$
16 	-		$K_\tau = \sqrt{3}\left\{5.34 + Max\left[\frac{4}{\alpha^2}; \frac{7.15}{\alpha^{2.5}}\right]\right\}$	
17 	-		$K_\tau = K' r$ K' = K according to case 15 r: opening reduction factor taken as $r = \left(1 - \frac{d_a}{a}\right)\left(1 - \frac{d_b}{b}\right)$ with $\frac{d_a}{a} \le 0.7$ and $\frac{d_b}{b} \le 0.7$	
18. 	-		$K_\tau = 3^{0.5}(0.6 + 4/\alpha^2)$	

Table 2 Buckling Factor and reduction factor for plane plate panels (continued)

Case	Stress ratio (ψ)	Aspect ratio (α)	Buckling factor (K)	Reduction factor (C)
19. 	-	α	$K_\tau = 8$	
Edge boundary conditions: ------ Plate edge free. ——— Plate edge simply supported. ━━━ Plate edge clamped.				
Notes: 1) Cases listed are general cases. Each stress component(σ_x, σ_y) is to be understood in local coordinates.				

2.2 Curved plate panels

This requirement for curved plate limit state is applicable when $R/t_p \leq 2500$. Otherwise, the requirement for plate limit state given in **2.1.1** is applicable.

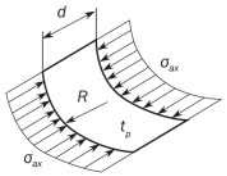
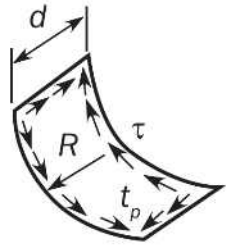
$$\left(\frac{\gamma_c \sigma_{ax}}{C_{ax} R_{eH\_p}}\right)^{1.25} + \left(\frac{\gamma_c \tau \sqrt{3}}{C_\tau R_{eH\_p}}\right)^2 = 1.0$$

where,

σ_{ax} : Applied axial stress($\mathrm{N/mm^2}$) to the cylinder corresponding to the curved plate panel, In case of tensile axial stresses, σ_{ax} = 0.
C_{ax}, C_τ : Reduction factor of the curved plate panel, as defined in **Table 3.**

The stress multiplier factor, γ_c of the curved plate panel needs not be taken less than the stress multiplier factor, γ_c for the expanded plane panel according to **2.1.1.**

Table 3 Buckling Factor and reduction factor for curved plate panel with $R/t_p \leq 2500$

Case	Aspect ratio	Buckling factor (K)	Reduction factor (C)
1 	$\frac{d}{R} \leq 0.5\sqrt{\frac{R}{t_p}}$	$K = 1 + \frac{2}{3}\frac{d^2}{Rt_p}$	For general application: $C_{ax} = 1,$ for $\lambda \leq 0.25$ $C_{ax} = 1.233 - 0.933\lambda$ for $0.25 < \lambda \leq 1$ $C_{ax} = 0.3/\lambda^3,$ for $1 < \lambda \leq 1.5$ $C_{ax} = 0.2/\lambda^2,$ for $\lambda > 1.5$ For curved single fields, e.g. bilge strake, which are bounded by plane panels: $C_{ax} = \frac{0.65}{\lambda^2} \leq 1.0$
	$\frac{d}{R} > 0.5\sqrt{\frac{R}{t_p}}$	$K = 0.267\frac{d^2}{Rt_p}[3 - \frac{d}{R}\sqrt{\frac{t_p}{R}}] \geq 0.4\frac{d^2}{Rt_p}$	
2 	$\frac{d}{R} \leq 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\sqrt{28.3 + \frac{0.67d^3}{R^{1.5}t_p^{1.5}}}$	$C_\tau = 1,$ for $\lambda \leq 0.4$ $C_\tau = 1.274 - 0.686\lambda,$ for $0.4 < \lambda \leq 1.2$ $C_\tau = \frac{0.65}{\lambda^2},$ for $\lambda > 1.2$
	$\frac{d}{R} > 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\frac{0.28d^2}{R\sqrt{Rt_p}}$	
Explanations for boundary conditions: ——— Plate edge simply supported			

3. Buckling capacity of overall stiffened panel

The elastic stiffened panel limit state is based on the following interaction formula:

$$\frac{P_z}{c_f} = 1$$

where:

P_z and c_f are defined in 4.4.3.

4. Buckling capacity of longitudinal stiffeners

4.1 Stiffeners limit states

The buckling capacity of longitudinal stiffeners is to be checked for the following limit states:

- Stiffener induced failure (SI)
- Associated plate induced failure (PI)

4.2 Lateral pressure

The lateral pressure is to be considered as constant in the buckling strength assessment of longitudinal stiffeners.

4.3 Stiffener idealization

4.3.1 Effective length of the stiffener

The effective length of the stiffener, $\ell_{eff}(\mathrm{mm})$is to be taken equal to:

- $\ell_{eff} = \frac{\ell}{\sqrt{3}}$ for stiffener fixed at both ends.
- $\ell_{eff} = 0.75\ell$ for stiffener simply supported at one end and fixed at the other
- $\ell_{eff} = \ell$ for stiffener simply supported at both ends.

4.3.2 Effective width of the attached plating, b_{eff1}

The effective width of the attached plating of a stiffener, $b_{eff1}(\mathrm{mm})$ without the shear lag effect is to be taken equal to:

$$b_{eff1} = \frac{C_{\chi 1} b_1 + C_{\chi 2} b_2}{2}$$

where:

$C_{\chi 1}, C_{\chi 2}$: Reduction factor defined in **Table 2** calculated for the EPP1 and EPP2 on each side of the considered stiffener according to case 1.

b_1, b_2 : Width (mm) of plate panel on each side of the considered stiffener

4.3.3 Effective width of attached plating, b_{eff}

The effective width of attached plating of stiffeners, $b_{eff}(\mathrm{mm})$ is to be taken as:

$$b_{eff} = \mathrm{Min}(\mathrm{b_{eff1}}, \chi_s \mathrm{s})$$

where:

χ_s : Effective width coefficient to be taken as:

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

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

4.3.4 Net thickness of attached plating

The net thickness of plate, $t_p(\mathrm{mm})$ is to be taken as the mean thickness of the two attached plating panels.

4.3.5 Effective web thickness of flat bar

For accounting the decrease of stiffness due to local lateral deformation, the effective web thickness (mm) of flat bar stiffener is to be used for the calculation of the net sectional area, A_s the net section modulus, Z and the moment of inertia, I of the stiffener and is taken as:

$$t_{w-red} = t_w\left[1-\frac{2\pi^2}{3}\left(\frac{h_w}{s}\right)^2\left(1-\frac{b_{eff1}}{s}\right)\right] \qquad \text{(mm)}$$

4.3.6 Net section modulus Z of a stiffener

Net section modulus, Z of a stiffener including effective width of plating, b_{eff} is to be taken equal to:

- the section modulus calculated at the top of stiffener flange for stiffener induced failure (SI).
- the section modulus calculated at the attached plating for plate induced failure (PI).

4.3.7 Net moment of inertia, I of a stiffener

The net moment of inertia, I (cm^4) of a stiffener including effective width of attached plating, b_{eff} to comply with the following requirement:

$$I \geq \frac{s\,t_p^3}{12\times10^4}$$

4.3.8 Idealization of bulb profile

Bulb profiles may be considered as equivalent angle profiles. The net dimensions of the equivalent built-up section are to be obtained from the following formulae.

$$h_w = h'_w - \frac{h'_w}{9.2} + 2 \qquad (\mathrm{mm})$$

$$b_f = \alpha\left(t'_w + \frac{h'_w}{6.7} - 2\right) \qquad (\mathrm{mm})$$

$$t_f = \frac{h'_w}{9.2} - 2 \qquad (\mathrm{mm})$$

$$t_w = t'_w \qquad (\mathrm{mm})$$

where:

h'_w, t'_w : Net height and thickness (mm) of a bulb section as shown in **Fig A2.2**.

α : Coefficient equal to:

$$\alpha = 1.1 + \frac{(120 - h'_w)^2}{3000} \quad \text{for } h'_w \leq 120$$

$$\alpha = 1.0 \quad \text{for } h'_w \rangle 120$$

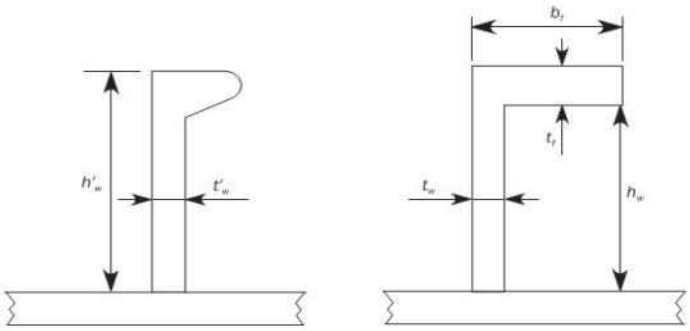


Fig A2.2 Idealization of bulb stiffener

4.4 Ultimate buckling capacity

4.4.1 Longitudinal stiffener limit state

When $\sigma_a + \sigma_b + \sigma_w > 0$ the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

$$\frac{\gamma_c \sigma_a + \sigma_b + \sigma_w}{R_{eH}} = 1$$

where:

σ_a : Effective axial stress (N/mm^2) at mid-span of the stiffener, defined in **4.4.2**

σ_b : Bending stress (N/mm^2) in the stiffener, defined in **4.4.3**

σ_w : Stress (N/mm^2) due to torsional deformation, defined in **4.4.4**

R_{eH} : Specified minimum yield stress (N/mm^2) of the material

- $R_{eH} = R_{eH-S}$ for stiffener induced failure (SI)
- $R_{eH} = R_{eH-P}$ for plate induced failure (PI)

4.4.2 Effective axial stress, σ_a

The effective axial stress (N/mm^2) at mid-span of the stiffener, acting on the stiffener with its attached plating is to be taken equal to:

$$\sigma_a = \sigma_x \frac{s\, t_p + A_s}{b_{eff1}\, t_p + A_s}$$

where:

σ_x : Nominal axial stress (N/mm^2) acting on the stiffener with its attached plating, calculated according to **4.4.1** at load calculation point of the stiffener

A_S : Net sectional area (mm^2) of the considered stiffener

4.4.3 Bending stress, σ_b

The bending stress in the stiffener $(\mathrm{N/mm^2})$ is to be taken equal to:

$$\sigma_b = \frac{M_0 + M_1}{Z \times 10^3}$$

where:

M_1 : Bending moment $(\mathrm{N/mm})$ due to the lateral load, P

$$M_1 = C_i \frac{|P|\, s\, \ell^2}{24 \times 10^3} \quad \text{for continuous stiffener}$$

$$M_1 = C_i \frac{|P|\, s\, \ell^2}{8 \times 10^3} \quad \text{for sniped stiffener}$$

P : Lateral load $(\mathrm{kN/m^2})$ to be taken equal to the static pressure at the load calculation point of the stiffener.

C_i : Pressure coefficient

C_i = C_{SI} for stiffener induced failure (SI)

C_i = C_{PI} for plate induced failure (PI)

C_{PI} : Plate induced failure pressure coefficient

C_{PI} = 1 if the lateral pressure is applied on the side opposite to the stiffener

C_{PI} = −1 if the lateral pressure is applied on the same side as the stiffener

C_{SI} : Stiffener induced failure pressure coefficient

C_{SI} = −1 if the lateral pressure is applied on the side opposite to the stiffener

C_{SI} = 1 if the lateral pressure is applied on the same side as the stiffener

M_0 : Bending moment $(\mathrm{N/mm})$ due to the lateral deformation, w of stiffener

$$M_0 = F_E\left(\frac{P_z w}{c_f - P_z}\right) \quad \text{with} \quad c_f - P_z > 0$$

F_E : Ideal elastic buckling force (N) of the stiffener

$$F_E = \left(\frac{\pi}{\ell}\right)^2 EI10^4$$

P_z : Nominal lateral load $(\mathrm{N/mm^2})$ acting on the stiffener due to stresses σ_x and τ, in the attached plating in way of the stiffener mid span:

$$P_z = \frac{t_p}{s}\left(\sigma_{xI}\left(\frac{\pi s}{\ell}\right)^2 + \sqrt{2}\,\tau_1\right)$$

$$\sigma_{x\ell} = \gamma_c \sigma_x \left(1 + \frac{A_s}{s\, t_p}\right) \quad \text{but not less than 0}$$

$$\tau_1 = \gamma_c |\tau| - t_p \sqrt{R_{eH\_p} E\left(\frac{m_1}{a^2} + \frac{m_2}{s^2}\right)} \quad \text{but not less than 0}$$

m_1, m_2 : Coefficients taken equal to:

$m_1 = 1.47$, $m_2 = 0.49$ for $\alpha \geq 2$

$m_1 = 1.96$, $m_2 = 0.37$ for $\alpha < 2$

w : Deformation of stiffener (mm) taken equal to:

$$w = w_0 + w_1$$

w_0 : Assumed imperfection (mm), taken equal to:

$w_0 = \ell/1000$ in general

$w_0 = -w_{na}$ for stiffeners sniped at both ends, considering stiffener induced failure (SI)

$w_0 = w_{na}$ for stiffeners sniped at both ends, considering plate induced failure (PI)

w_{na} : Distance (mm) from the mid-point of attached plating to the neutral axis of the stiffener calculated with the effective width of the attached plating, b_{eff}

w_1 : Deformation (mm) of stiffener at midpoint of stiffener span due to lateral load, P. In case of uniformly distributed load, w_1 is to be taken as:

$$w_1 = C_i \frac{|P|s\,\ell^4}{384 \times 10^7 EI}, \qquad \text{in general}$$

$$w_1 = C_i \frac{5|P|sI^4}{384.10^7 EI}, \qquad \text{for stiffener sniped at both ends}$$

c_f : Elastic support provided by the stiffener ($\mathrm{N/mm^2}$) to be taken equal to:

$$c_f = F_E \left(\frac{\pi}{\ell}\right)^2 (1 + c_p)$$

c_p : Coefficient to be taken as:

$$c_p = \frac{1}{1 + \frac{0.91}{c_{xa}} \left(\frac{12\,I10^4}{s\,t_p^3} - 1\right)}$$

c_{xa} :

$$c_{xa} = \left(\frac{\ell}{2s} + \frac{2s}{\ell}\right)^2 \qquad \text{for} \quad \ell \geq 2s$$

$$c_{xa} = \left(1 + \left(\frac{\ell}{2s}\right)^2\right)^2 \qquad \text{for} \quad \ell < 2s$$

4.4.4 Stress due to torsional deformation, σ_w

The stress due to torsional deformation, $\sigma_w (\mathrm{N/mm^2})$ is to be taken equal to:

$$\sigma_w = E\,y_w \left(\frac{t_f}{2} + h_w\right) \Phi_0 \left(\frac{\pi}{\ell}\right)^2 \left(\frac{1}{1 - \frac{0.4\,R_{eH\_S}}{\sigma_{ET}}} - 1\right) \qquad \text{for stiffener induced failure (SI)}$$

$$\sigma_w = 0 \qquad \text{for plate induced failure (PI)}$$

where:

y_w : Distance (mm) from centroid of stiffener cross-section to the free edge of stiffener flange, to be taken as:

$$y_w = \frac{t_w}{2}, \qquad \text{for flat bar}$$

$$y_w = b_f - \frac{h_w t_w^2 + t_f b_f^2}{2A_s}, \qquad \text{for angle and bulb profiles}$$

$$y_w = \frac{b_f}{2} \qquad \text{for Tee profile}$$

$$\Phi_0 = \frac{\ell}{h_w} 10^{-3}$$

σ_{ET} : Reference stress for torsional buckling $(\mathrm{N/mm^2})$

$$\sigma_{ET} = \frac{E}{I_p}\left(\frac{\epsilon \pi^2 I_w 10^2}{\ell^2} + 0.385 I_T\right)$$

I_P : Net polar moment of inertia $(\mathrm{cm^4})$ of the stiffener about point C as shown in **Fig A2.3**, as defined in **Table 4**

I_T : Net St. Venant's moment of inertia $(\mathrm{cm^4})$ of the stiffener, as defined in **Table 4**

I_w : Net sectional moment of inertia $(\mathrm{cm^6})$ of the stiffener about point C as shown in **Fig A2.3,** as defined in **Table 4**

ϵ : Degree of fixation

$$\epsilon = 1 + \frac{\left(\frac{\ell}{\pi}\right)^2 10^{-3}}{\sqrt{I_w\left(\frac{0.75s}{t_p^3} + \frac{e_f - 0.5t_f}{t_w^3}\right)}}$$

Table 4 Moments of inertia

	Flat bars	Bulb, angle and Tee profiles
I_p	$\frac{h_w^3 t_w}{3 \times 10^4}$	$\left(\frac{A_w (e_f - 0.5t_f)^2}{3} + A_f e_f^2\right) 10^{-4}$
I_T	$\frac{h_w^3 t_w}{3 \times 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$	$\frac{(e_f - 0.5t_f) t_w^3}{3 \times 10^4}\left(1 - 0.63\frac{t_w}{e_f - 0.5t_f}\right) + \frac{b_f t_f^3}{3 \times 10^4}\left(1 - 0.63\frac{t_f}{b_f}\right)$
I_w	$\frac{h_w^3 t_w^3}{36 \times 10^6}$	$\frac{A_f e_f^2 b_f^2}{12 \times 10^6}\left(\frac{A_f + 2.6A_W}{A_f + A_W}\right)$: for bulb and angle profiles $\frac{b_f^3 t_f e_f^2}{12 \times 10^6}$, : for Tee profiles
A_w : Net web area $(\mathrm{mm^2})$ A_f : Net flange area $(\mathrm{mm^2})$		

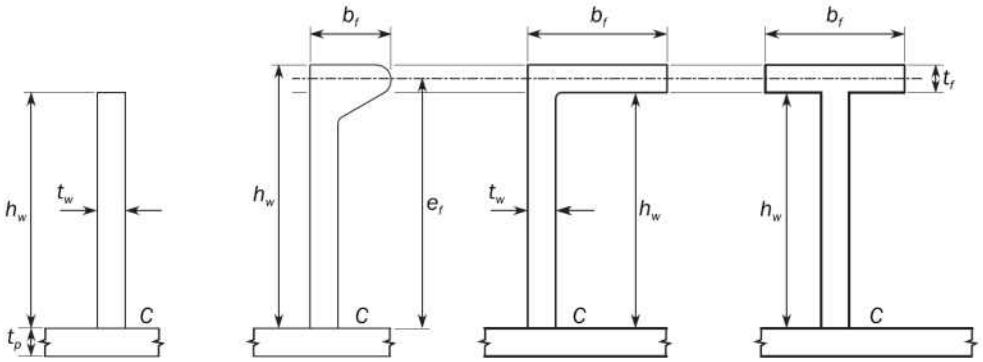


Fig A2.3 Stiffener cross sections

Appendix 3 - Hull girder ultimate bending capacity

Symbols

I_{y-net} : Net moment of inertia (m^4) of the hull transverse section around its horizontal neutral axis

Z_{B-net}, Z_{D-net} : Section moduli. (m^3) at bottom and deck, respectively

R_{e_Hs} : Minimum yield stress $(\mathrm{N/mm^2})$ of the material of the considered stiffener

R_{e_Hp} : Minimum yield stress $(\mathrm{N/mm^2})$ of the material of the considered plate

A_{s-net} : Minimum yield stress (cm^2) of the material of the considered plate

A_{p-net} : Net sectional area (cm^2) of attached plating

1. General Assumptions

1.1

The method for calculating the ultimate hull girder capacity is to identify the critical failure modes of all main longitudinal structural elements.

1.2

Structures compressed beyond their buckling limit have reduced load carrying capacity. All relevant failure modes for individual structural elements, such as plate buckling, torsional stiffener buckling, stiffener web buckling, lateral or global stiffener buckling and their interactions, are to be considered in order to identify the weakest inter-frame failure mode.

2. Incremental-iterative method

2.1 Assumptions

In applying the incremental-iterative method, the following assumptions are generally to be made:

- The ultimate strength is calculated at hull transverse sections between two adjacent transverse webs
- The hull girder transverse section remains plane during each curvature increment.
- The hull material has an elasto-plastic behaviour.
- The hull girder transverse section is divided into a set of elements, see **2.2.2**, which are considered to act independently.

According to the iterative procedure, the bending moment, M_i acting on the transverse section at each curvature value, χ_i is obtained by summing the contribution given by the stress, σ acting on each element. The stress, σ corresponding to the element strain, ε is to be obtained for each curvature increment from the non-linear load-end shortening curves, $\sigma-\varepsilon$ of the element.

These curves are to be calculated, for the failure mechanisms of the element, from the formulae specified in **2.3.** The stress, σ is selected as the lowest among the values obtained from each of the considered load-end shortening curves, $\sigma-\varepsilon$.

The procedure is to be repeated until the value of the imposed curvature reaches the value $\chi_F(\mathrm{m}^{-1})$ in hogging and sagging condition, obtained from the following formula:

$$\chi_F = \pm 0.003 \frac{M_y}{EI_{y-net}}$$

where:

M_y : Lesser of the values M_{Y1} and M_{Y2} (kNm)

$$M_{Y1} = 10^3 R_{eH} Z_{B-net}$$

$$M_{Y2} = 10^3 R_{eH} Z_{D-net}$$

If the value χ_F is not sufficient to evaluate the peaks of the curve, $M_{-\chi}$ the procedure is to be repeated until the value of the imposed curvature permits the calculation of the maximum bending moments of the curve

2.2 Procedure

2.2.1 General

The curve M_{-x} is to be obtained by means of an incremental-iterative approach, summarized in the flow chart in **Fig A3.1.**

In this procedure, the ultimate hull girder bending moment capacity, M_U is defined as the peak value of the curve with vertical bending moment, M versus the curvature, χ of the ship cross section as shown in **Fig A3.1**. The curve is to be obtained through an incremental-iterative approach.

Each step of the incremental procedure is represented by the calculation of the bending moment, M_i which acts on the hull transverse section as the effect of an imposed curvature, χ_i.

For each step, the value, χ_i is to be obtained by summing an increment of curvature, $\triangle\chi$ to the value relevant to the previous step χ_{i-1}. This increment of curvature corresponds to an increment of the rotation angle of the hull girder transverse section around its horizontal neutral axis.

This rotation increment induces axial strains, ε in each hull structural element, whose value depends on the position of the element. In hogging condition, the structural elements above the neutral axis are lengthened, while the elements below the neutral axis are shortened, and vice-versa in sagging condition.

The stress, σ induced in each structural element by the strain, ε is to be obtained from the load-end shortening curve, $\sigma-\varepsilon$ of the element, which takes into account the behaviour of the element in the non-linear elasto-plastic domain.

The distribution of the stresses induced in all the elements composing the hull transverse section determines, for each step, a variation of the neutral axis position due to the nonlinear $\sigma-\varepsilon$, relationship. The new position of the neutral axis relevant to the step considered is to be obtained by means of an iterative process, imposing the equilibrium among the stresses acting in all the hull elements on the transverse section.

Once the position of the neutral axis is known and the relevant element stress distribution in the section is obtained, the bending moment of the section, M_i round the new position of the neutral axis, which corresponds to the curvature, χ_i imposed in the step considered, is to be obtained by summing the contribution given by each element stress.

The main steps of the incremental-iterative approach described above are summarized as follows (see also **Fig A3.1**):

a) Step 1 : Divide the transverse section of hull into stiffened plate elements
b) Step 2 : Define stress-strain relationships for all elements as shown in **Table 1**
c) Step 3 : Initialize curvature, χ_1 and neutral axis for the first incremental step with the value of incremental curvature (i.e. curvature that induces a stress equal to 1% of yield strength in strength deck) as:

$$\chi_1 = \triangle\chi = 0.01\frac{R_{eH}}{E}\frac{1}{z_D - z_n}$$

where:

z_D : Z coordinate (m) of strength deck at side

z_n : Z coordinate (m) of horizontal neutral axis of the hull transverse section with respect to the reference coordinate system defined in **1.2.3**

d) Step 4 : Calculate for each element the corresponding strain, $\varepsilon_i = \chi(z_i - z_n)$ and the corresponding stress, σ_i

e) Step 5 : Determine the neutral axis, z_{NA-cur} at each incremental step by establishing force equilibrium over the whole transverse section as:

$$\Sigma A_{i-net}\sigma_i = \Sigma A_{j-net}\sigma_j$$

(i-th element is under compression, j-th element under tension)

f) Step 6 : Calculate the corresponding moment by summing the contributions of all elements as:

$$M_u = \Sigma \sigma_{Ui} A_{i-net} |(z_i - z_{NA-cur})|$$

g) Step 7 : Compare the moment in the current incremental step with the moment in the previous incremental step. If the slope in M_{-x} relationship is less than a negative fixed value, terminate the process and define the peak value, M_U. Otherwise, increase the curvature by the amount of, $\triangle\chi$ and go to Step **4**.

2.2.2 Modelling of the hull girder cross section

Hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder ultimate strength. Sniped stiffeners are also to be modelled, taking account that they do not contribute to the hull girder strength. The structural members are categorized into a stiffener element, a stiffened plate element or a hard corner element. The plate panel including web plate of girder or side stringer is idealized into a stiffened plate element, an attached plate of a stiffener element or a hard corner element.

The plate panel is categorized into the following two kinds:

- Longitudinally stiffened panel of which the longer side is in ship's longitudinal direction, and
- Transversely stiffened panel of which the longer side is in the perpendicular direction to ship's longitudinal direction.

a) Hard corner element

Hard corner elements are sturdier elements composing the hull girder transverse section, which collapse mainly according to an elasto-plastic mode of failure (material yielding); they are generally constituted by two plates not lying in the same plane.

The extent of a hard corner element from the point of intersection of the plates is taken equal to $20t_{net}$ on a transversely stiffened panel and to $0.5s$ on a longitudinally stiffened panel, see **Fig A3.2.**

t_{net} : thickness of the plate (mm)

s : Spacing of the adjacent longitudinal stiffener (m)

Bilge, sheer strake-deck stringer elements, girder-deck connections and face plate-web connections on large girders are typical hard corners.

b) Stiffener element

The stiffener constitutes a stiffener element together with the attached plate.
The attached plate width is in principle:

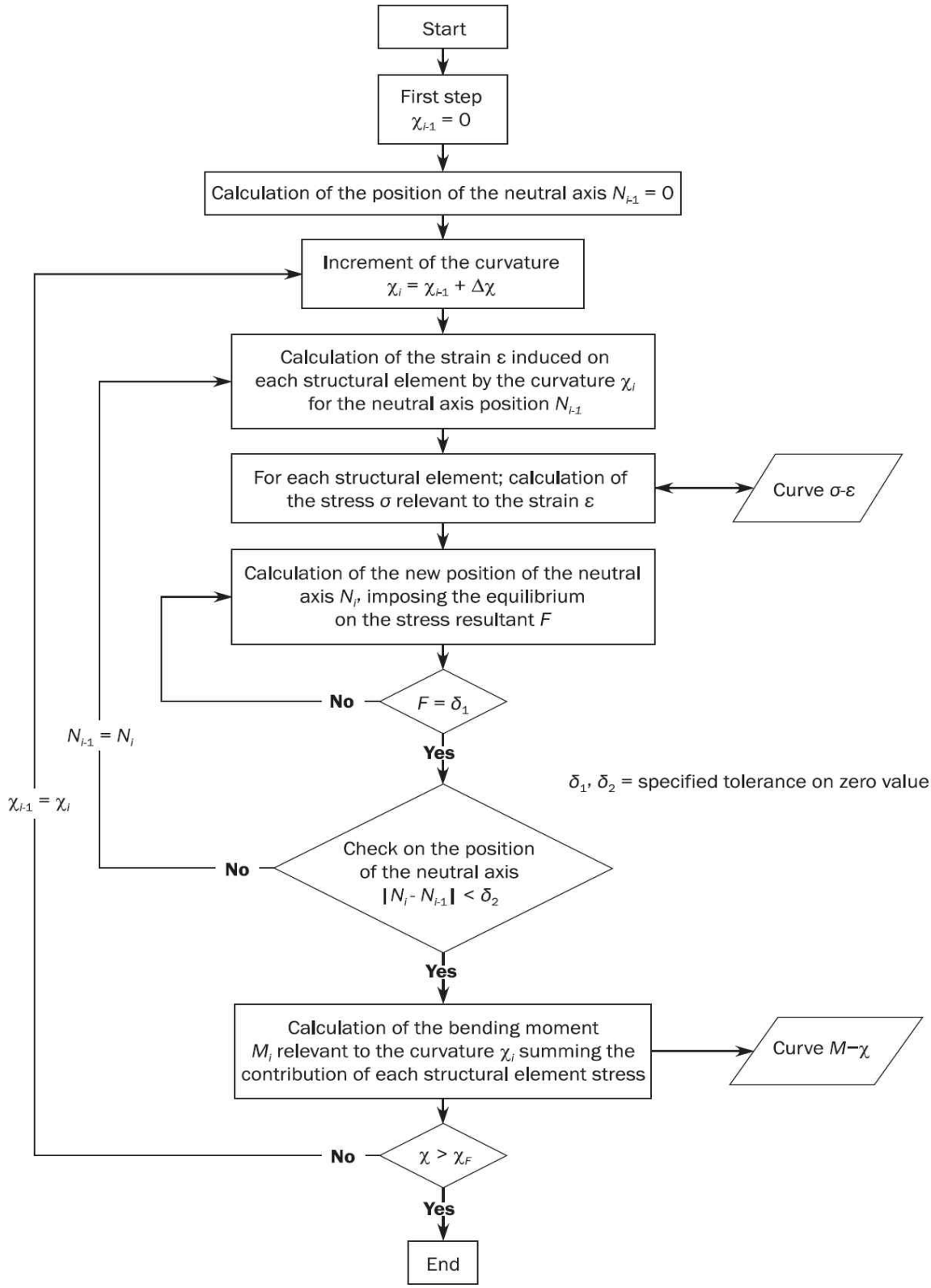


Fig A3.1 Flow chart of the procedure for the evaluation of the curve

- Equal to the mean spacing of the stiffener when the panels on both sides of the stiffener are longitudinally stiffened, or
- Equal to the width of the longitudinally stiffened panel when the panel on one side of the stiffener is longitudinally stiffened and the other panel is of the transversely stiffened, see Fig A3.2.

c) Stiffened plate element

The plate between stiffener elements, between a stiffener element and a hard corner element or between hard corner elements is to be treated as a stiffened plate element, see **Fig A3.2**.

The typical examples of modelling of hull girder section are illustrated in **Fig A3.3.**

Notwithstanding the foregoing principle, these figures are to be applied to the modelling in the vicinity of upper deck, sheer strake and hatch coaming.

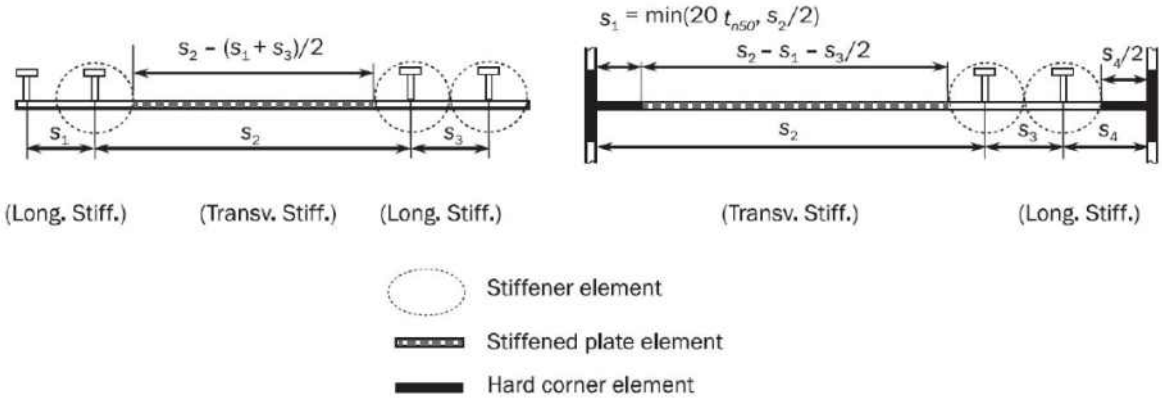


Fig A3.2 Extension of the breadth of the attached plating and hard corner element

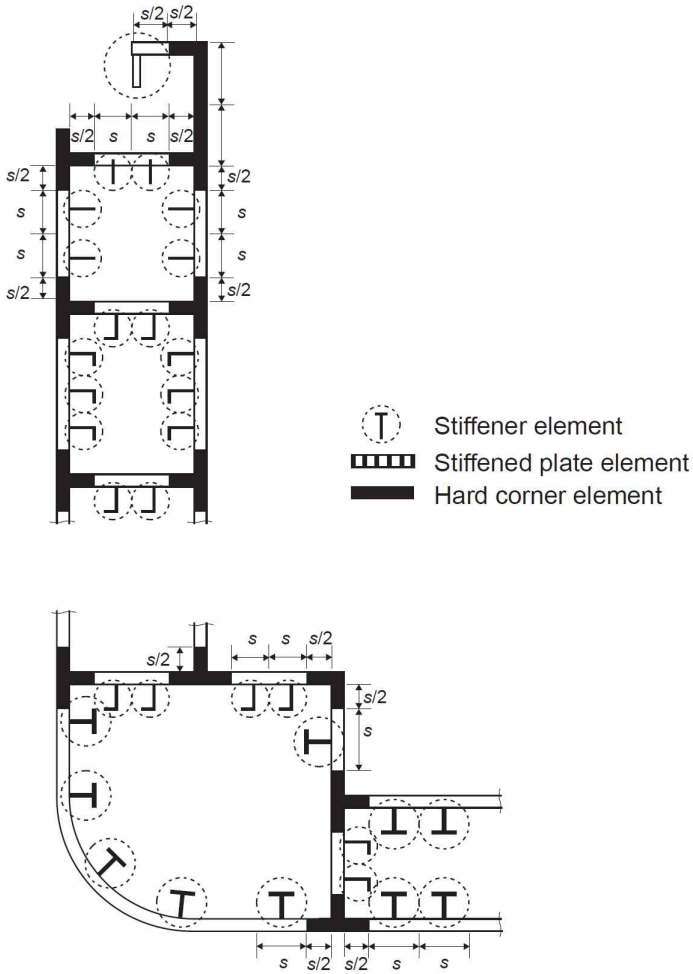


Fig A3.3 Examples of the configuration of stiffened plate elements, stiffener elements and hard corner elements on a hull section

- In case of the knuckle point as shown in **Fig A3.4,** the plating area adjacent to knuckles in the plating with an angle greater than 30 degrees is defined as a hard corner. The extent of one side of the corner is taken equal to 20 t_{net} on transversely framed panels and to 0.5 s on longitudinally framed panels from the knuckle point.
- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the non-continuous stiffeners are considered only as dividing a plate into various elementary plate panels.
- Where the opening is provided in the stiffened plate element, the openings are to be considered in accordance with the requirements of the Society.
- Where attached plating is made of steels having different thicknesses and/or yield stresses, an average thickness and/or average yield stress obtained from the following formula are to be used for the calculation

$$t_{net} = \frac{t_{1-net}s_1 + t_{2-net}s_2}{s} \qquad R_{e\_Hp} = \frac{R_{e\_Hp1}t_{1-net}s_1 + R_{eH\_p2}t_{2-net}s_2}{t_{net}S}$$

where, R_{eH_P1}, R_{eH_P2}, t_{1-net}, t_{2-net}, s_1, s_2 and s are shown in **Fig A3.5**.

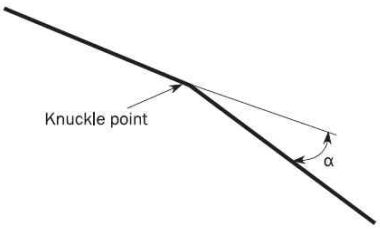


Fig A3.4 Plating with knuckle point

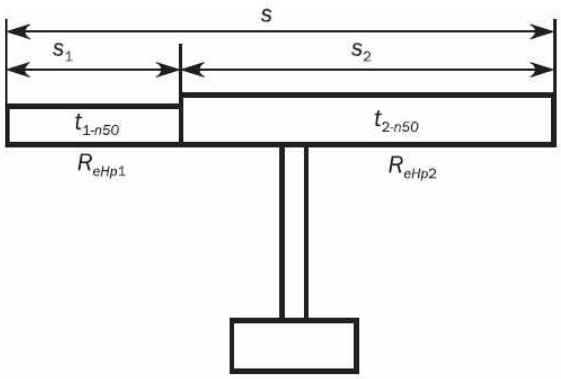


Fig A3.5 Element with different thickness and yield strength

2.3 Load-end shortening curves

2.3.1 Stiffened plate element and stiffener element

Stiffened plate element and stiffener element composing the hull girder transverse sections may collapse following one of the modes of failure specified in **Table 1.**

- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the stress of the element is to be obtained in accordance with **2.3.2** to **2.3.7**, taking into account the non-continuous longitudinal stiffener

- Where the opening is provided in the stiffened plate element, the considered area of the stiffened plate element is to be obtained by deducting the opening area from the plating in calculating the total forces for checking the hull girder ultimate strength.
- For stiffened plate element, the effective width of plate for the load shortening portion of the stress-strain curve is to be taken as full plate width, i.e. to the intersection of other plate or longitudinal stiffener - neither from the end of the hard corner element nor from the attached plating of stiffener element, if any. In calculating the total forces for checking the hull girder ultimate strength, the area of the stiffened plate element is to be taken between the hard corner element and the stiffener element or between the hard corner elements, as applicable.

Table 1 Modes of failure of stiffened plate element and stiffener element

Element	Mode of failure	Curve $\sigma-\varepsilon$ defined in
Lengthened stiffened plate element or stiffener element	Elasto-plastic collapse	2.3.2
Shortened stiffener element	Beam column buckling Torsional buckling Web local buckling of flanged profiles Web local buckling of flat bars	2.3.3 2.3.4 2.3.5 2.3.6
Shortened stiffened plate element	Plate buckling	2.3.7

2.3.2 Elasto-plastic collapse of structural elements (Hard corner element)

The equation describing the load-end shortening curve, $\sigma-\varepsilon$ for the elasto-plastic collapse of structural elements composing the hull girder transverse section is to be obtained from the following formula

$$\sigma = \Phi R_{eHA}$$

where:

R_{eHA} : Equivalent minimum yield stress $(\mathrm{N/mm^2})$ of the considered element, obtained by the following formula:

$$R_{eHA} = \frac{R_{eH\_P}A_{p-net} + R_{eH\_s}A_{s-net}}{A_{p-net} + A_{s-net}}$$

Φ : Edge function, equal to:

Φ = −1 for ε 〈 −1

$\Phi = \varepsilon$ for $-1 \le \varepsilon \le 1$

Φ = 1 for ε 〉 1

ε : Relative strain, equal to:

$$\varepsilon = \frac{\varepsilon_E}{\varepsilon_Y}$$

ε_E : Element strain

ε_Y : Strain at yield stress in the element, equal to:

$$\varepsilon_Y = \frac{R_{eHA}}{E}$$

2.3.3 Beam column buckling

The positive strain portion of the average stress-average strain curve, $\sigma_{CR1}-\varepsilon$ based on beam column buckling of plate-stiffener combinations is described according to the following:

$$\sigma_{CR1} = \Phi\sigma_{C1}\frac{A_{s-net}+A_{pE-net}}{A_{s-net}+A_{p-net}}$$

where:

Φ : Edge function, as defined in **2.3.2**

σ_{C1} : Critical stress $(\mathrm{N/mm^2})$ equal to:

$$\sigma_{C1} = \frac{\sigma_{E1}}{\varepsilon} \quad \text{for} \quad \sigma_{E1} \le \frac{R_{eHB}}{2}\varepsilon$$

$$\sigma_{C1} = R_{eHB}\left(1-\frac{R_{eHB}\varepsilon}{4\sigma_{E1}}\right) \quad \text{for} \quad \sigma_{E1} > \frac{R_{eHB}}{2}\varepsilon$$

R_{eHB} : Equivalent minimum yield stress $(\mathrm{N/mm^2})$ of the considered element, obtained by the following formula:

$$R_{eHB} = \frac{R_{eH\_P}A_{pEI-n50}\ell_{pE}+R_{eH\_S}A_{s-net}\ell_{sE}}{A_{pEI-net}\ell_{pE}+A_{s-net}\ell_{sE}}$$

$A_{pEI-net}$: Effective area $(\mathrm{cm^2})$ equal to:

$$A_{pEI-net} = 10b_{E1}t_{net}$$

ℓ_{pE} : Distance (mm) measured from the neutral axis of the stiffener with attached plate of width, b_{E1} to the bottom of the attached plate

ℓ_{sE} : Distance (mm) measured from the neutral axis of the stiffener with attached plate of width, b_{E1} to the top of the stiffener

ε : Relative strain, as defined in **2.3**

σ_{E1} : Euler column buckling stress $(\mathrm{N/mm^2})$ equal to:

$$\sigma_{E1} = \pi^2 E\frac{I_{E-net}}{A_{E-net}\ell^2}10^{-4}$$

I_{E-net} : Net moment of inertia of stiffeners $(\mathrm{cm^4})$ with attached plate of width, b_{E1}

A_{E-net} : Net area $(\mathrm{cm^2})$ of stiffeners with attached plating of width, b_E

b_{E1} : Effective width corrected for relative strain (m) of the attached plating, equal to:

$$b_{E1} = \frac{s}{\beta_E} \quad \text{for} \quad \beta_E > 1.0$$

$$b_{E1} = s \quad \text{for} \quad \beta_E \le 1.0$$

$$\beta_E = 10^3\frac{s}{t_{net}}\sqrt{\frac{\varepsilon R_{eH\_P}}{E}}$$

A_{pE-net}: Net area $(\mathrm{cm^2})$ of attached plating of width, b_E, equal to:

$$A_{pE-net} = 10\,b_E\,t_{net}$$

b_E : Effective width (m) of the attached plating, equal to:

$$b_E = \left(\frac{2.25}{\beta_E}-\frac{1.25}{\beta_E^2}\right)s \quad \text{for} \quad \beta_E > 1.25$$

$$b_E = s \quad \text{for} \quad \beta_E \le 1.25$$

2.3.4 Torsional buckling

The load-end shortening curve, $\sigma_{CR2}-\varepsilon$ for the flexural-torsional buckling of stiffeners composing the hull girder transverse section is to be obtained according to the following formula:

$$\sigma_{CR2} = \Phi \frac{A_{s-net}\sigma_{C2} + A_{p-net}\sigma_{CP}}{A_{s-net} + A_{p-net}}$$

where:

Φ : Edge function, as defined in **2.3.2**

σ_{C2} : Critical stress $(\mathrm{N/mm^2})$ equal to:

$$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon} \quad \text{for} \quad \sigma_{E2} \le \frac{R_{eH\_s}}{2}\varepsilon$$

$$\sigma_{C2} = R_{eH\_s}\left(1 - \frac{R_{eH\_s}\varepsilon}{4\sigma_{E2}}\right) \quad \text{for} \quad \sigma_{E2} > \frac{R_{eH\_s}}{2}\varepsilon$$

ε : Relative strain, as defined in **2.3.2**

σ_{E2} : Column buckling stress $(\mathrm{N/mm^2})$ taken as σ_{ET} defined in **Appendix 2 4.4.4**

σ_{CP} : Buckling stress of the attached plating $(\mathrm{N/mm^2})$ equal to:

$$\sigma_{CP} = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)R_{eH\_P} \quad \text{for} \quad \beta_E > 1.25$$

$$\sigma_{CP} = R_{eH\_P} \quad \text{for} \quad \beta_E \le 1.25$$

β_E : Coefficient, as defined in **2.3.3**

2.3.5 Web local buckling of stiffeners made of flanged profiles

The load-end shortening curve, $\sigma_{CR3}-\varepsilon$ for the web local buckling of flanged stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR3} = \Phi \frac{10^3 b_E t_{net} R_{eH\_p} + (h_{we}t_{w-net} + b_f t_{f-net})R_{eH\_s}}{10^3 s t_{net} + h_w t_{w-net} + b_f t_{f-net}}$$

where:

Φ : Edge function, as defined in **2.3.2**

b_E : Effective width (m) of the attached plating, as defined in **2.3.3**

h_{we} : Effective height (mm) of the web, equal to:

$$h_{we} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2}\right)h_w \quad \text{for} \quad \beta_w > 1.25$$

$$h_{we} = h_w \quad \text{for} \quad \beta_w \le 1.25$$

$$\beta_w = \frac{h_w}{t_{w-net}}\sqrt{\frac{\varepsilon R_{eH\_s}}{E}}$$

ε : Relative strain, as defined in **2.3.2**

2.3.6 Web local buckling of stiffeners made of flat bars

The load-end shortening curve, $\sigma_{CR4}-\varepsilon$ for the web local buckling of flat bar stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR4} = \Phi\frac{A_{P-net}\sigma_{CP}+A_{s-net}\sigma_{C4}}{A_{p-net}+A_{s-net}}$$

where:

Φ : Edge function, as defined in **2.3.2**

σ_{CP} : Buckling stress of the attached plating $(\mathrm{N/mm^2})$ as defined in **2.3.4**

σ_{C4} : Critical stress $(\mathrm{N/mm^2})$ equal to:

$$\sigma_{C4} = \frac{\sigma_{E4}}{\varepsilon} \quad \text{for} \quad \sigma_{E4} \le \frac{R_{eH\_s}}{2}\varepsilon$$

$$\sigma_{C4} = R_{eH\_s}\left(1-\frac{R_{eH\_s}\varepsilon}{4\sigma_{E4}}\right) \quad \text{for} \quad \sigma_{E4} > \frac{R_{eH\_s}}{2}\varepsilon$$

σ_{E4} : Local Euler buckling stress $(\mathrm{N/mm^2})$ equal to

$$\sigma_{E4} = 160{,}000\left(\frac{t_{w-net}}{h_w}\right)^2$$

ε : Relative strain, as defined in **2.3.2**

2.3.7 Plate buckling

The load-end shortening curve, $\sigma_{CR5}-\varepsilon$ for the buckling of transversely stiffened panels composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR5} = \mathrm{Min}\left\{\begin{array}{l}\mathrm{R_{eH\_p}}\Phi \\ \Phi\mathrm{R_{eH\_p}}\left[\frac{\mathrm{s}}{\ell}\left(\frac{2.25}{\beta_{\mathrm{E}}}-\frac{1.25}{\beta_{\mathrm{E}}^2}\right)^{\mathrm{R_{eH\_p}}\Phi}+0.1\left(1-\frac{\mathrm{s}}{\ell}\right)\left(1+\frac{1}{\beta_{\mathrm{E}}^2}\right)^2\right]\end{array}\right\}$$

where:

Φ : Edge function, as defined in **2.3.2**

β_E : Coefficient as defined in **2.3.3**

s : Plate breadth (m) taken as the spacing between the stiffeners

ℓ : Longer side of the plate (m)

3. Alternative methods

3.1 General

3.1.1

Application of alternative methods is to be agreed by the Society prior to commencement. Documentation of the analysis methodology and detailed comparison of its results are to be submitted for review and acceptance. The use of such methods may require the partial safety factors to be recalibrated.

3.1.2

The bending moment-curvature relationship $(M-\chi)$ may be established by alternative methods. Such models are to consider all the relevant effects important to the non-linear response with due considerations of:

a) Non-linear geometrical behaviour

b) Inelastic material behaviour
c) Geometrical imperfections and residual stresses (geometrical out-of-flatness of plate and stiffeners
d) Simultaneously acting loads:
  • Bi-axial compression.
  • Bi-axial tension.
  • Shear and lateral pressure
e) Boundary conditions
f) Interactions between buckling modes
g) Interactions between structural elements such as plates, stiffeners, girders, etc.
h) Post-buckling capacity
i) Overstressed elements on the compression side of hull girder cross section possibly leading to local permanent sets/buckle damages in plating, stiffeners etc. (double bottom effects or similar)

3.2 Non-linear finite element analysis

3.2.1

Advanced non-linear finite element analyses models may be used for the assessment of the hull girder ultimate capacity. Such models are to consider the relevant effects important to the non-linear responses with due consideration of the items listed in **3.1.2.**

3.2.2

Particular attention is to be given to modelling the shape and size of geometrical imperfections. It is to be ensured that the shape and size of geometrical imperfections trigger the most critical failure modes. ⚓

Annex 7-10 Guidance for Direct Strength Assessment for Ore Carriers
(2020) 【See Rule】

(1) General

The direct strength calculation of the ore carrier is in accordance with following (1) to (9) and proceeds according to the structural analysis flow chart in **Fig 1**. The members that can determine the scantling by direct strength calculation are as follows. Bottom transverse, deck transverse, side transverse, longitudinal bulkhead transverse, cross-tie, floor, inner bottom, bottom shell, side shell, cross deck and girder. Gross thickness is applied for the direct strength calculation. The buckling strength is evaluated for net thickness considering the corrosion margin defined in following (7).

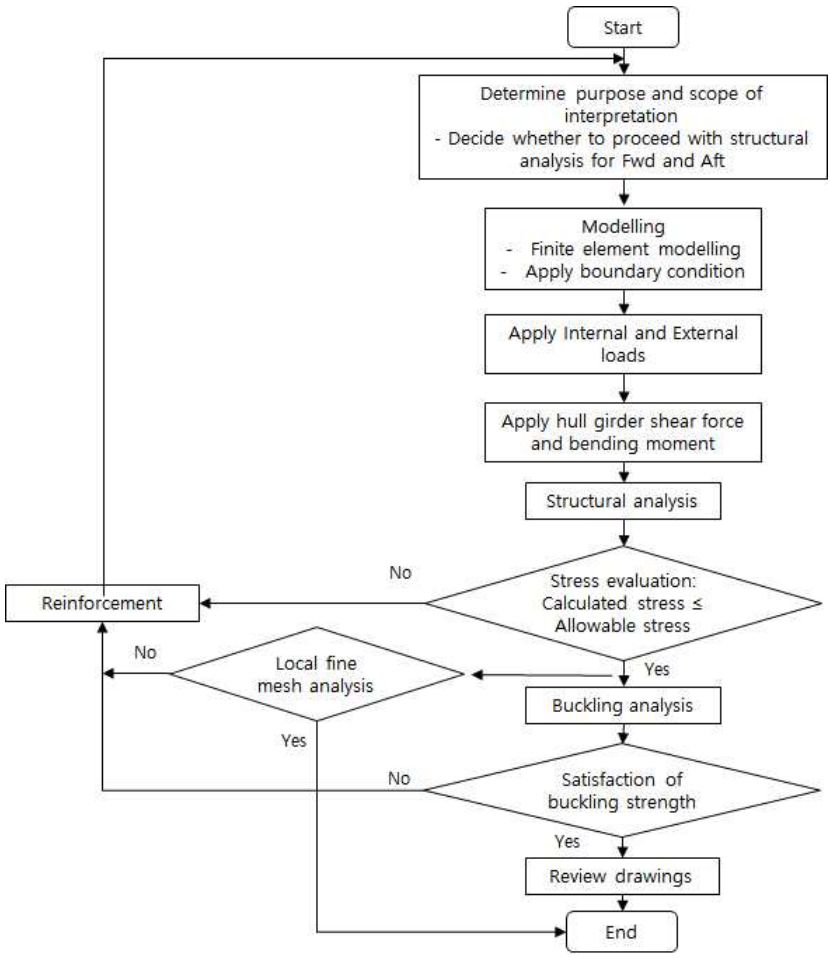


Fig 1 Structural analysis flow of cargo hold and froe/aft structure

(2) Modelling

The procedure of structural modelling for mid cargo hold(or tank)is to be as follows:

(A) Range of analysis

(a) The analysis of the mid-cargo hold structure should be carried out to reflect the structural strength assessment from the No. 2 cargo hold to the No. n-1 cargo hold. In addition, the bow structure analysis should be carried out to reflect the structural strength evaluation of No.1 cargo hold, and the stern structure analysis should be carried out to reflect the structural strength evaluation of the No. n cargo hold.

(b) The longitudinal extent of the finite element model of the mid-hold is to include three cargo holds and four transverse bulkheads as shown in **Fig 2**. The transverse bulkheads at both ends of the model range should be included with the connected stool. Both ends of the model shall form a vertical plane and, if applicable, shall include all transverse web frames on the plane. The model should be made in both port and starboard.

(c) The Fwd and Aft models should be extend to the fore peak for the Fwd part and after end transverse bulkhead for Aft part including the full length of the cargo hold, as shown in Fig 3 to Fig 5. The range of analysis should be determined taking into consideration the cargo/ the ballast conditions and the longitudinal/lateral symmetry of the bulkhead/the girders attached to the bulkheads. In the Fwd model, from the center of the collision bulkhead and fore peak to the fore peak, the forward hull form and cross section can be modeled with a simplified geometry. In the Aft model, from middle of machinery space to the after end transverse bulkhead can be modelled with a simplified geometry.

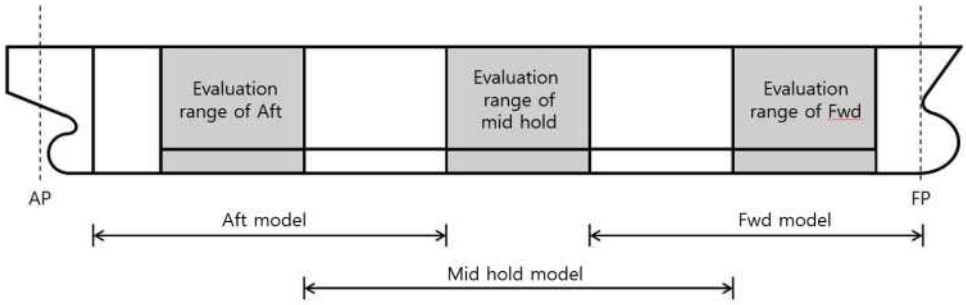


Fig 2 Model and evaluation range

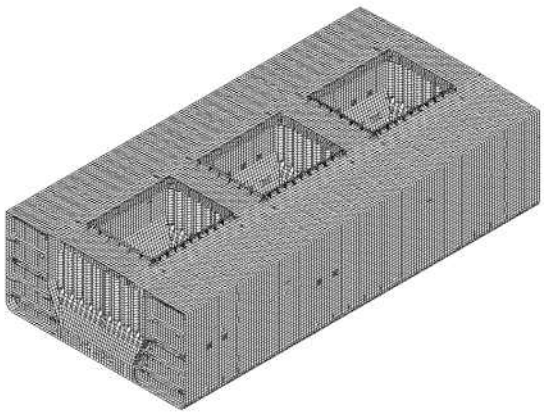


Fig 3 Example of structural modelling

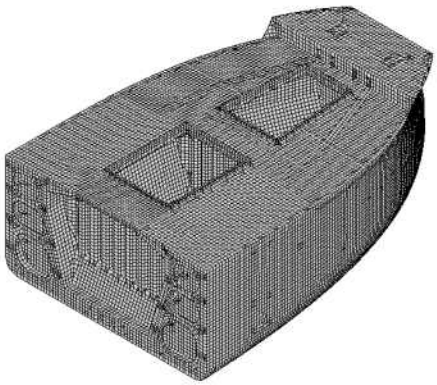


Fig 4 Example of Fwd modelling

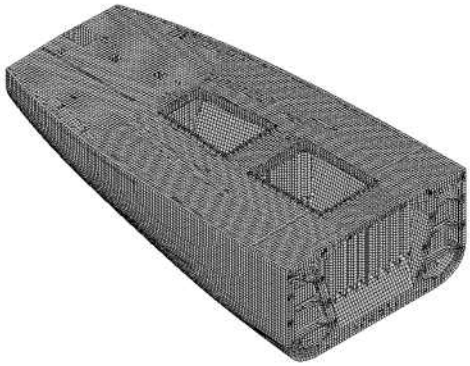


Fig 5 Example of Aft model

(B) Structural modelling

The following (a) to (g) apply to element meshing of structural model.

(a) In meshing, proper sizes of meshes are to be selected by predicting the stress distribution in the model, and the aspect ratio should not exceed 3.

(b) Girders and similar members having stress gradients along their depth are to be so meshed as to enable their discrimination.

(c) The length of the short side of each mesh is to be restricted to longitudinal spacing or thereabouts.

(d) All stiffeners are to be modeled as beam elements with axial, torsional, shear, bending stiffness. Also, an offset beam considering the eccentricity of the stiffener should be used.

(e) The flanges of primary support members and brackets are to be modeled using rods or beam elements.

(f) The coordinate system of the model is used as shown in **Table 1**.

(g) The method of indicating openings in the web of primary supporting members is to be in accordance with **Table 2**. If the openings are not modeled, the shear stresses near the openings shall be modified in accordance with the reduction of the shear area along the actual openings. And the modified shear stress should be used to calculate the equivalent stress of the element for verification of the yield criterion.

Table 1 Co-ordinate system

	Direction	Direction Remark
X	Longitudinal	Positive forward
Y	Transverse	Positive to port
Z	Vertical	Positive upwards from the baseline

Table 2 Representation of openings in web of primary support member

$h_0/h < 0.5$ and $g_0 < 2.0$	No need to model the openings
$h_0/h \geq 0.5$ and $g_0 \geq 2.0$	Need to model the openings

Where :

$$g_0 = (1 + \frac{l_0^2}{2.6(h-h_0)^2})$$

l_0 : The length of the opening parallel to the longitudinal direction of the primary support member web. (m, see **Fig 6**) For continuous openings where the distance d_0 between openings is less than $0.25h$, the length l_0 should be the length across the opening as shown in **Fig 7**

h_0 : Height of opening parallel to the depth direction of the web (m, see **Fig 6** and **Fig 7**)

h : Height of primary support member web where opening is located (m, see **Fig 6** and **Fig 7**)

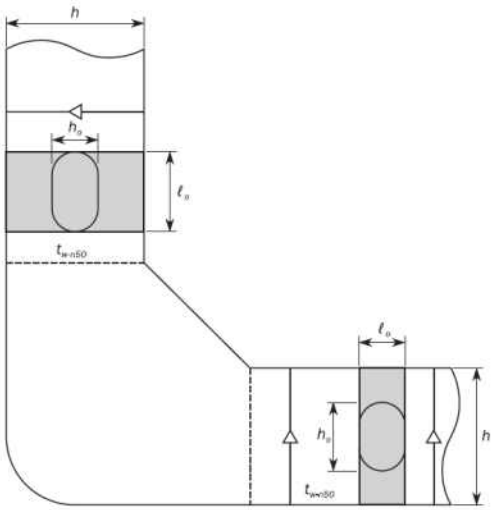


Fig 6 Opening in the web

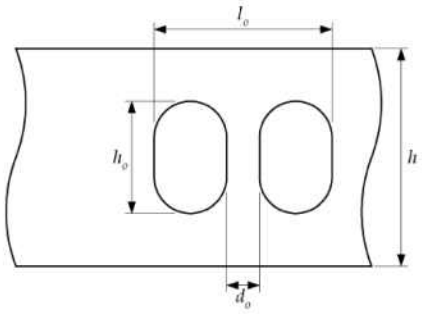


Fig 7 Opening in the web

(3) Boundary condition

(A) The boundary conditions and supporting conditions of the structural model should be able to reasonably implement the behavior of the structural model according to the range of the model. Both ends of the model are simply supported in accordance with **Table 3** and **4**. The joints on the longitudinal strength members at both ends should be rigidly connected to the independent joints on the neutral axis on the ship's centerline as shown in **Table 3**. The independent nodes at both ends should be fixed as shown in **Table 4**.

Table 3 Rigid connections at both ends of the model

Rigid - connection	Displacement			Rotation		
	U_x	U_y	U_z	θ_x	θ_y	θ_z
Longitudinal strength member nodes of front end of model	-	RL	RL	RL	-	-
Longitudinal strength member nodes of after end of model	-	RL	RL	RL	-	-
RL means that the related degrees of freedom of independent nodes are rigidly connected.						

Table 4 Support conditions at model independent nodes

Location of independent nodes	Displacement			Rotation		
	U_x	U_y	U_z	θ_x	θ_y	θ_z
Independent nodes of front end of model	-	Fix	Fix	Fix	-	-
Independent nodes of after end of model	-	Fix	Fix	Fix	-	-
Intersection of centerline and inner bottom plate	Fix					

(4) Applied loads

(A) Internal loads

(a) Loads due to ore cargo, grain cargo, etc. are as follows;

(i) The height and surface of the cargo are to be determined in accordance with below (see **Fig 8, 9** and **10**)

- The shape of cargo surface is assumed to be horizontal longitudinally and transversely and sloped down straight to the ship's sides with the half angle of repose (ψ). (If the hold is not uniformed in longitudinally and transversely by hopper sloped angle, it is assumed that the middle section of the cargo hold is uniformed in longitudinally.)
- The width of the horizontal part b_{iB} is assumed to be equal to 1/4 of the breadth of the hold.
- The loading height h_c is determined in accordance with the mass, angle of repose and density of the cargo to be loaded. The shape of cargo surface may be assumed to be unchanged for the whole breadth above.
- The density and repose angel of cargo should be considered as follows.

	Density of cargo γ ($\mathrm{ton/m^3}$)	Repose angle $\psi(^\circ)$
Low density cargo	M' / V_H (≥ 1.0)	35
High density cargo	3.0	35[1)]
[1)] If there is a repose angle other than 35°, this angle should be additionally considered.		

M' : Cargo weight of the cargo hold. The following formula is applied.

$$M' = M + \frac{1}{n} Min(3000,\ 0.1M)\ \ (t)$$

M : Maximum permissible bulk cargo weight of the cargo hold (t)
n : Minimum number of loading in one cargo hold
V_H : Volume, in m^3, of cargo hold up to level of the intersection of the main deck with the hatch coaming excluding the volume enclosed by hatch coaming.

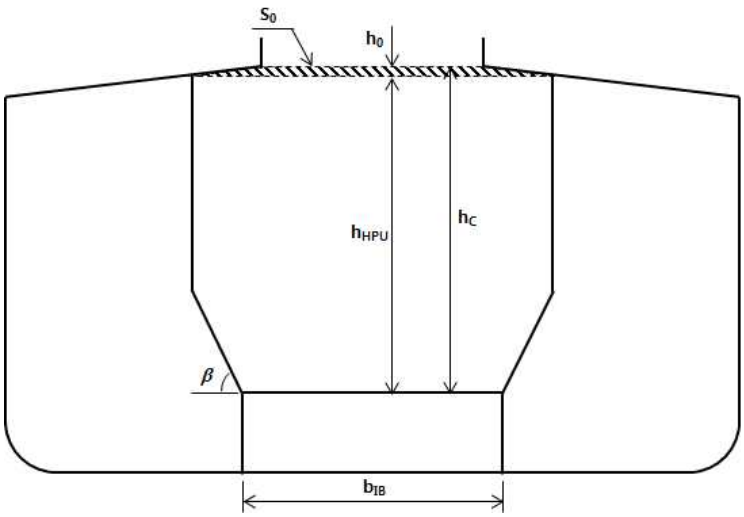


Fig 8 Assumed cargo surface (low density)

(ii) The loads on the vertical walls of the hold are to be determined by the following formula.

$$w = 9.81\gamma h K_C \qquad (\mathrm{kN/m^2})$$

where;

γ : Density of cargo($\mathrm{kg/m^3}$)

h : Vertical distance from the panel in consideration to the surface of the cargo right above the panel (m)

K_C : $\cos^2\beta + (1-\sin\psi)\sin^2\beta$

β : Angle between slant plating of the bilge hopper and inner bottom plating(see **Fig 8**)

ψ : Repose angle (see **Fig 9**)

- The load of low density cargo on the inner wall of the cargo hold is given by the following formula.

$$h_c = h_{HPU} + h_0$$

where;

$$h_0 = \frac{S_A}{B_H}$$

$$S_A = S_o + \frac{V_{HC}}{l_H}$$

h_{HPU} : Vertical distance (m) between inner bottom and lower intersection of top side tank and side shell or inner side

S_o : Shaded area ($\mathrm{m^2}$) above the lower intersection of top side tank and side shell or inner side and up to the upper deck level

V_{HC} : Volume ($\mathrm{m^3}$) enclosed by the hatch coaming

- The load of high density cargo on the inner wall of the cargo hold is given by the following formula.

if $h_1 \geq 0$ (see **Fig 9**)

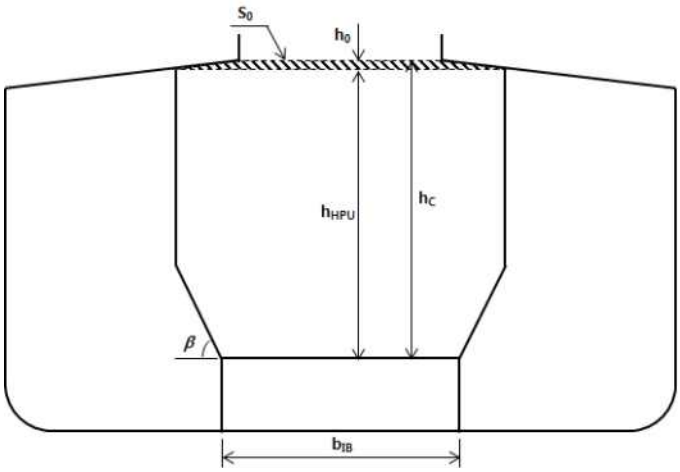


Fig 9 Assumed cargo surface (low density)

$$h_C = h_{HPL} + h_1 + h_2$$

Where;

h_{HPL} : Vertical distance between inner bottom plate and top intersection of hopper tank and inner plate(m)

h_1 : Vertical distance(m) is as follows;

$$h_1 = \frac{M'}{\rho B_H l_H} - \frac{B_H + b_{IB}}{2 B_H} h_{HPL} - \frac{3}{16} B_H \tan\frac{\psi}{2} + \frac{V_{TS}}{B_H l_H}$$

Where;

B_H : Breadth of cargo hold(m)

l_H : Length of cargo hold(m)

b_{IB} : Breadth of double bottom(m)

V_{TS} : The total volume(m^3) of the transverse stool at the bottom of the transverse bulkhead within the cargo hold length, l_H considered. In this volume, the volume of the portion of the hopper tank passing through the transverse bulkhead is excluded.

h_2 : The height(m) of the upper surface of the bulk cargo along the width, as follows;

$$h_2 = \frac{B_H}{4}\tan\frac{\psi}{2}, \quad \text{if } 0 \leqq |y| \leqq \frac{B_H}{4}$$

$$h_2 = \left(\frac{B_H}{2} - |y|\right)\tan\frac{\psi}{2}, \quad \text{if } \frac{B_H}{4} \leqq |y| \leqq \frac{B_H}{2}$$

if $h_1 < 0$ (see **Fig 10**)

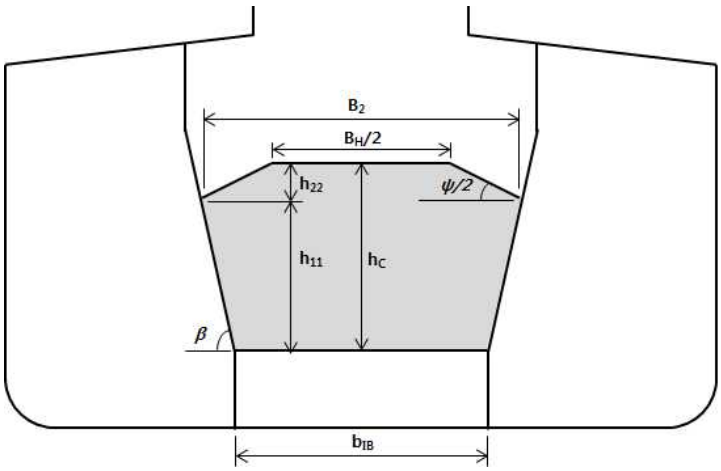


Fig 10 Assumed cargo surface(high density, $h_1 < 0$)

$$h_C = h_{11} + h_{22}$$

Where;

h_{11} : Vertical distance(m) is as follows;

$$h_{11} = h_{HPL}\left(\frac{B_2 - b_{IB}}{B_H - b_{IB}}\right)$$

h_{22} : Vertical distance(m) is as follows;

$$h_{22} = \left(\frac{B_2}{2} - \frac{B_H}{4}\right)\tan\frac{\psi}{2}$$

$$B_2 = \sqrt{\frac{\frac{1}{l_H}\left(\frac{M'}{\rho_c} + V_{TS}\right) + \frac{1}{2}\left(\frac{h_{HPL} \cdot b_{IB}^2}{B_H - b_{IB}}\right) + \frac{B_H^2}{16}\tan\frac{\psi}{2}}{\frac{1}{2}\left[\left(\frac{h_{HPL}}{B_H - b_{IB}}\right) + \frac{1}{2}\tan\frac{\psi}{2}\right]}}$$

- In order to evaluate the total force in the vertical direction, shear loads acting on the slope plate of the bilge hopper tank and lower stool by bulk dry bulk cargo are to be taken into account. The shear load acting on the sloped members by the ore cargo in the still water is given by the following formula.

$$w_{sh} = 9.81\gamma\frac{(1 - K_C)(h_C + h_{DB} - z)}{\tan\beta}\ (\mathrm{kN/m^2})$$

where;

z : vertical distance from inner bottom plate to considered point

(b) Loads due to ballast water
The water head of the each location in ballast hold is to be determined by the following formula.

$$h_W = \mathrm{Max}(0.85(\mathrm{h} + \triangle\mathrm{h}), \mathrm{h}) \quad (\mathrm{m})$$

where;

h : Vertical distance measured from the position under consideration to 1/2 of overflow pipes(m)

$\triangle h$: The value is to be obtained from following formula;
$\triangle h = 16/L(l_t - 10) + 0.25(b_t - 10)$

l_t : tank length (m). however, where it is less than 10 (m), it is to be taken as 10.

b_t : tank breadth (m). however, where it is less than 10 (m), it is to be taken as 10.

(c) Load under hydrostatic test
The water head of the tank to be subjected to the hydrostatic test should be the tank top + 2.4 m

(B) Hydrostatic pressure
The hydrostatic pressure is to be in accordance with **Pt. 3 Annex 3-2, III 1** (8).

(C) Wave loads
The wave loads are to be in accordance with **Pt. 3 Annex 3-2, III 1** (9).

(D) Hull weight
Consider the self weight of the hull considering gravitational acceleration.

(E) Load due to upper structure
If the upper structure is included in structural model, the load considered with acceleration of gravity are to be considered. If the upper structure is not included in structural model, loads on upper structure are to be distributed on relevant deck nodes.

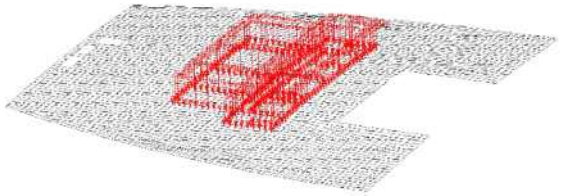


Fig 11 Loads due to upper structure

(F) Load due to the main engine
The loads due to the main engine are to be distributed on relevant nodes of M/E foundation.



Fig 12 Loads due to main engine

(G) Consideration of hull girder shear force
(a) The hull girder shear force is to be calculated at the position of the transverse bulkhead of the mid hold, and the target value is determined as follows. In addition, the sign in each transverse bulkhead is applied in the same way as the loading conditions in **Table 5, 6** and **7**.

$$Q_{targ} = F_s + F_w$$

where:
F_s : shear force in still water (kN)
F_w : wave shear force according to **Pt 3, Ch. 3, 301.**

(b) For mid hold, shear force is to comply with **Pt 13, Sub-Pt. 1, Ch. 7 Sec. 2**. For Fwd and Aft hold, shear force is to comply with **Pt 13, Sub-Pt. 1, Ch. 7 Sec. 2.**
(c) The direct calculation of the shear flow is to comply with **Pt 13, Sub-Pt. 1, Ch. 5, Annex 1.**

(H) Considering of hull girder vertical bending moment
(a) The hull girder vertical bending moment is adjusted after adjusting the shear force.
(b) In the analysis of the vertical bending moment, the target hull girder vertical bending moment is the maximum vertical bending moment that can occur at the center of the mid hold in the finite element model. The target value of the hull girder vertical bending moment is obtained as follows.

$$M_{v-targ} = M_s + M_w$$

where;
M_s : vertical bending moment in still water (kNm)
M_w : wave vertical bending moment according to **Pt 3, Ch. 3 Table 3.3.1**

(c) The distribution of hull girder vertical bending moments caused by local loads applied to the model is calculated using simple beam theory in accordance with **Pt. 13, Sub-Pt. 1, Ch. 7, Sec. 2.**

(d) If the target vertical bending moment has to be reached, an additional vertical bending moment should be applied to both ends of the hold model to generate this target value in the center hold of the model. These end vertical bending moments are as follows.

$$M_{Y-aft} = M_{v-targ} - M_{V\_FEM}(x_{v-max})$$

$$M_{Y-fwd} = - M_{Y-aft}$$

where

x_{v-max} : Longitudinal position where maximum bending moment occurs due to local load in mid hold(m)

M_{Y-fwd} : additional vertical bending moments applied to the forward end of the finite element model (kNm)

M_{Y-aft} : additional vertical bending moments applied to the after end of the finite element model (kNm)

M_{V-peak} : maximum or minimum bending moments in the mid hold by local load and shear force adjustment (kNm)

(e) The vertical bending moment adjustment procedure for the fore and aft part structural analysis is to comply with the requirements in **Pt. 13, Sub-Pt. 1, Ch. 7 Sec. 2. and 4.4.9**.

(l) Load case

The loading conditions to be considered are based on loading (high / low density), ballast loading, multi port loading and port loading. If special load cases are to be expected, such loading conditions are also included in the calculation. The load case for mid hold, aft hold and fwd hold are shown in **Table 5, 6** and **7**. Load cases may be changed according to loading manual, loading sequence and compartment layout. If there is no multi port cases in the loading manual, the multi port cases in **Table 5, 6** and **7** can be omitted and is given the **no MP** notation.

Table 5 Load case of Mid hold

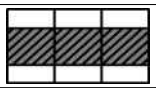
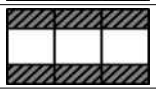
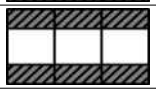
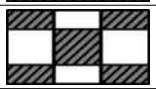
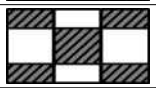
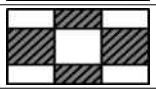
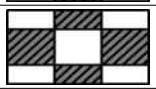
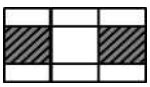
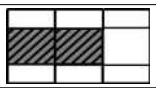
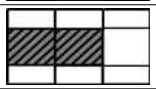
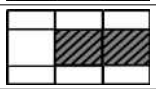
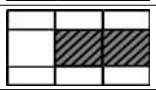
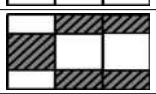
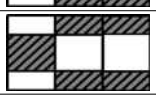
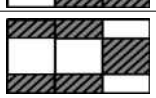
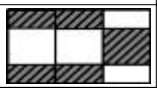
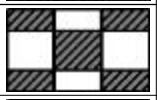
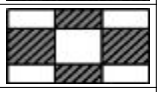
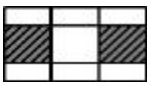
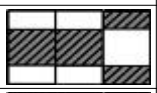
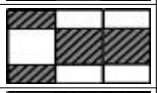
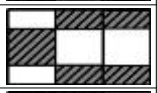
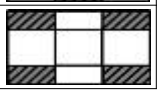
Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
at sea	1	Full load (1)	T_s	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	2	Full load (2)	T_s	Crest	High/Low density		0%[11]	100% (Hog)	-	-
at sea	3	Ballast (Normal)	T_{bal}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	4	Ballast (Heavy)	T_{bar-H}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	5	Multi port (1)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	6	Multi port (2)	$T_{multi-min}$[1]	Crest	High/Low density		0%[11]	100% (Hog)	-	-
at sea	7	Multi port (3)	$T_{multi-max}$[2]	Trough	High/Low density		0%[11]	100% (Sag)	-	-
at sea	8	Multi port (4)	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	-	-
at sea	9	Multi port (5)[7]	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	Fore[5] : +100% Aft[6] : -100%	Fore[5] : +100% Aft[6] : -100%
at sea	10	Multi port (6)[8]	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	Fore[5] : -100% Aft[6] : +100%	Fore[5] : -100% Aft[6] : +100%
at sea	11	Multi port (7)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	12	Multi port (8)	$T_{multi-min}$[1]	Crest	High/Low density		0%[11]	100% (Hog)	-	-
at sea	13	Multi port (9)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	14	Multi port (10)	$T_{multi-min}$[1]	Crest	High/Low density		0%[11]	100% (Hog)	-	-
at sea	15	Multi port (11)	$T_{multi-max}$[2]	Trough	High/Low density		0%[11]	100% (Sag)	-	-
at sea	16	Multi port (12)	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	-	-
at sea	17	Multi port (13)	$T_{multi-max}$[2]	Trough	High/Low density		0%[11]	100% (Sag)	-	-

Table 5 Load case of Mid hold (continued)

Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
at sea	18	Multi port (14)[7]	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	–	–
port	19	Port (1)	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	–	–	–
port	20	Port (2)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	–	–	–
port	21	Port (3)[9]	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	–	Fore[5] : +100% Aft[6] : −100%	– –
port	22	Port (4)[10]	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	–	Fore[5] : −100% Aft[6] : +100%	– –
port	23	Port (5)	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	–		
port	24	Port (6)	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	–	–	–
port	25	Port (7)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	–	–	–
port	26	Port (8)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	–	–	–
tank	27	Tank test (1)	$T_{sc}/3$	Hydrostatic pressure	–		–	–	–	–
tank	28	Tank test (2)	$T_{sc}/3$	Hydrostatic pressure	–		–	–	–	–

(Note)
The load cases can be changed / added in accordance with the loading manual. If there is no multi port cases in the loading manual, the multi port cases in **Table 5** can be omitted and is given the **no MP** notation.
1) $T_{multi-min}$: meet the maximum allowable cargo mass (see(9))
2) $T_{multi-max}$: meet the minimum required cargo mass (see(9))
3) $T_{harbour-min}$: meet the maximum allowable cargo mass (see(9))
4) $T_{harbour-max}$: meet the minimum allowable cargo mass (see(9))
5) Fore : The sign of the target shear force of forward transverse bulkhead of the center hold
6) Aft : The sign of the target shear force of aftward transverse bulkhead of the center hold
7) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Multi port (1) condition.
8) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Multi port (4) condition.
9) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Port (1) condition.
10) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Port (2) condition.
11) 0%* : Refer to loading manual.

Table 6 Load case of Aft hold

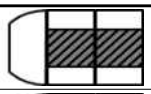
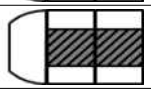
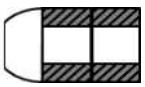
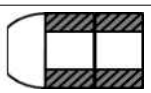
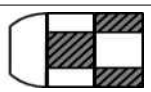
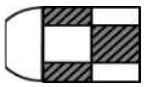
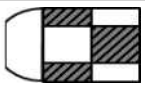
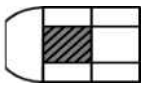
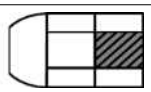
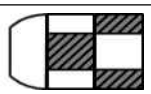
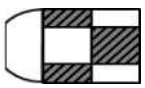
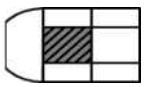
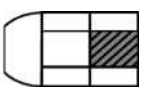
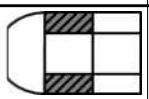
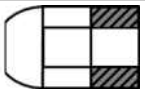
Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
at sea	1	Full load (1)	T_s	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	2	Full load (2)	T_s	Crest	High/Low density		0%[9]	100% (Hog)	-	-
at sea	3	Ballast (Normal)	T_{bal}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	4	Ballast (Heavy)	T_{bal-H}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	5	Multi port (1)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	6	Multi port (2)	$T_{multi-min}$[1]	Crest	High/Low density		0%[9]	100% (Hog)	-	-
at sea	7	Multi port (3)	$T_{multi-max}$[2]	Trough	High/Low density		0%[9]	100% (Sag)	-	-
at sea	8	Multi port (4)	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	-	-
at sea	9	Multi port (5)[7]	$T_{multi-min}$[1]	Crest	High/Low density		100% (Sag)	100% (Sag)	Fore[5]: +100% Aft[6] : -100%	Fore[5]: +100% Aft[6] : -100%
at sea	10	Multi port (6)	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	-	-
port	11	Port (1)	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	-	-	-
port	12	Port (2)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	-	-	-
port	13	Port (3)[8]	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	-	Fore[5]: +100% Aft[6]: -100%	- -
port	14	Port (4)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	-	-	-

Table 6 Load case of Aft hold (continued)

Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
tank	15	Tank test (1)	$T_{sc}/3$	Hydrostatic pressure	-		-	-	-	-
tank	16	Tank test (2)	$T_{sc}/3$	Hydrostatic pressure	-		-	-	-	-

(Note)
The load cases can be changed / added in accordance with the loading manual. If there is no multi port cases in the loading manual, the multi port cases in **Table 6** can be omitted and is given the **no MP** notation.
1) $T_{multi-min}$: meet the maximum allowable cargo mass (see(9))
2) $T_{multi-max}$: meet the minimum required cargo mass (see(9))
3) $T_{harbour-min}$: meet the maximum allowable cargo mass (see(9))
4) $T_{harbour-max}$: meet the minimum allowable cargo mass (see(9))
5) Fore : The sign of the target shear force of forward transverse bulkhead of the center hold
6) Aft : The sign of the target shear force of aftward transverse bulkhead of the center hold
7) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Multi port (1) condition.
8) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Port (1) condition.
9) 0%* : Refer to loading manual.

Table 7 Load case of Fwd hold

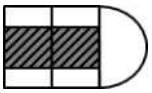
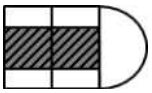
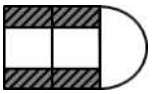
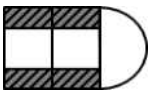
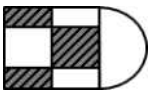
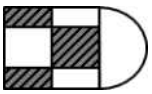
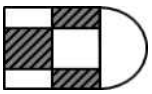
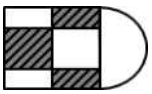
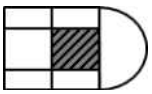
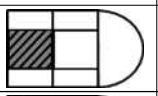
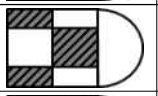
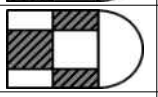
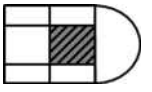
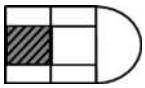
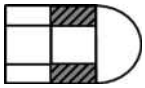
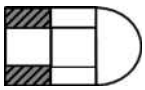
Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
at sea	1	Full load (1)	T_s	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	2	Full load (2)	T_s	Crest	High/Low density		0%[9]	100% (Hog)	-	-
at sea	3	Ballast (Normal)	T_{bal}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	4	Ballast (Heavy)	T_{bal-H}	Crest	-		100% (Hog)	100% (Hog)	-	-
at sea	5	Multi port (1)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	100% (Sag)	-	-
at sea	6	Multi port (2)	$T_{multi-min}$[1]	Crest	High/Low density		0%[9]	100% (Hog)	-	-
at sea	7	Multi port (3)	$T_{multi-max}$[2]	Trough	High/Low density		0%[9]	100% (Sag)	-	-
at sea	8	Multi port (4)	$T_{multi-max}$[2]	Crest	High/Low density		100% (Hog)	100% (Hog)	-	-
at sea	9	Multi port (5)7)	$T_{multi-min}$[1]	Trough	High/Low density		100% (Sag)	-	Fore[5] : +100% Aft[6] : -100%	- -
at sea	10	Multi port (6)	$T_{multi-max}$[1]	Crest	High/Low density		100% (Hog)	-	-	-
port	11	Port (1)	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	-	-	-
port	12	Port (2)	$T_{harbour-max}$[4]	Hydrostatic pressure	High/Low density		100% (Hog)	-	-	-
port	13	Port (3)[8]	$T_{harbour-min}$[3]	Hydrostatic pressure	High/Low density		100% (Sag)	-	Fore[5] : +100% Aft[6] : -100%	- -

Table 7 Load case of Fwd hold (continued)

Condition	No	Description	Draft	Wave load	Internal load	Loading pattern	Target bending moment and shear force			
							% of M_s	% of M_w	% of F_s	% of F_w
port	14	Port (4)	$T_{harbour-max}$ 4)	Hydrostatic pressure	High/Low density		100% (Hog)	-	-	-
tank	15	Tank test (1)	$T_{sc}/3$	Hydrostatic pressure	-		-	-	-	-
tank	16	Tank test (2)	$T_{sc}/3$	Hydrostatic pressure	-		-	-	-	-

(Note)
The load cases can be changed / added in accordance with the loading manual. If there is no multi port cases in the loading manual, the multi port cases in **Table 7** can be omitted and is given the **no MP** notation.
1) $T_{multi-min}$: meet the maximum allowable cargo mass (see(9))
2) $T_{multi-max}$: meet the minimum required cargo mass (see(9))
3) $T_{harbour-min}$: meet the maximum allowable cargo mass (see(9))
4) $T_{harbour-max}$: meet the minimum allowable cargo mass (see(9))
5) Fore : The sign of the target shear force of forward transverse bulkhead of the center hold
6) Aft : The sign of the target shear force of aftward transverse bulkhead of the center hold
7) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Multi port (1) condition.
8) If this loading condition is not taken into account, it should be evaluated in the loading condition of the Port (1) condition.
9) 0%* : Refer to loading manual.

(5) Consideration of dynamic shear loads in beam sea condition

(A) General

(a) In order to verify the structural integrity of transverse members under dynamic shear load due to rolling motion and high GM in beam sea condition, BSR and BSP load cases are to be applied as shown in **Table 8** and **Table 9.** BSR and BSP load cases means as follows;

- BSR-1P and BSR-2P : Beam sea EDWs that minimise and maximise the roll motion downward and upward on the port side respectively with waves from the port side.
- BSR-1S and BSR-2S : Beam sea EDWs that maximise and minimise the roll motion downward and upward on the starboard side respectively with waves from the starboard side.
- BSP-1P and BSP-2P : Beam sea EDWs that maximise and minimise the hydro-dynamic pressure at the waterline amidships on the port side respectively.
- BSP-1S and BSP-2S : Beam sea EDWs that maximise and minimise the hydro-dynamic pressure at the waterline amidships on the starboard side respectively.

(b) These BSR and BSP load cases are to be applied to homogeneous loading with $\gamma = 3.0$ $(\mathrm{ton/m^3})$ of high density cargo for mid hold model only. The loading pattern described in No. 1 condition of **Table 5.** should be applied.

(B) Applied loads

(a) The symbol's definitions in BSR and BSP load cases are following;

T_θ : The roll period, in s, is to be taken as;

$$T_\theta = \frac{2.3\pi k_r}{\sqrt{g\,GM}}.$$

where;

k_r : Roll radius of gyration, in m, in the considered loading condition. 0.25B is to be adopted unless provided in the loading manual.

GM : Metacentric height, in m, in the considered loading condition. 0.20B is to be adopted unless provided in the loading manual.

g : $9.81\,m/s^2$

θ : The roll angle, in deg, is to be taken as ;

$$\theta = \frac{9000(1.25-0.025\,T_\theta)f_{BK}}{(B+75)\pi}$$

where;

f_{BK} : To be taken as:

$f_{BK}=1.2$ for ships without bilge keel.

$f_{BK}=1.0$ for ships with bilge keel.

T_ϕ : The pitch period, in s, is to be taken as:

$$T_\phi = \sqrt{\frac{2.6\pi L}{g}}$$

ϕ : The pitch angle, in deg, is to be taken as:

$$\phi = 1350\,L^{-0.94}\left\{1+\frac{3.0}{\sqrt{gL}}\right\}$$

a_0 : Acceleration parameter, to be taken as:

$$a_0 = (1.58-0.47C_B)\left(\frac{2.4}{\sqrt{L}}+\frac{34}{L}-\frac{600}{L^2}\right)$$

x, y, z : X, Y and Z coordinates, in m, of the considered point at the intersection among the longitudinal plane of symmetry of ship, the aft end of L and the baseline.

R : Vertical coordinate, in m, of the ship rotation centre, to be taken as:

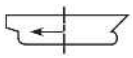
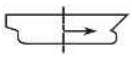
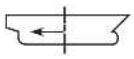
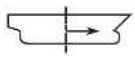
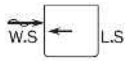
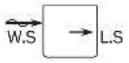
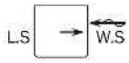
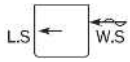
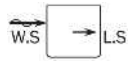
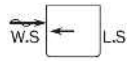
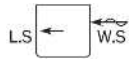
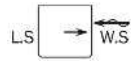
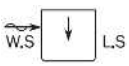
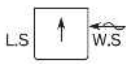
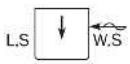
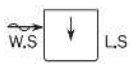
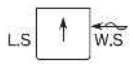
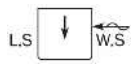
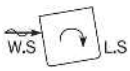
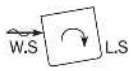
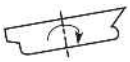
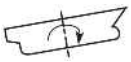
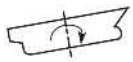
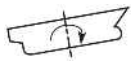
$$R = \min\left(\frac{D}{4}+\frac{T_{SC}}{2},\ \frac{D}{2}\right)$$

T_{SC} : Scantling draught

f_β : Heading correction factor, to be taken as:

$f_\beta=0.8$ for BSR and BSP load cases for the extreme sea loads design load scenario.

Table 6 Ship responses for BSR and BSP load cases

Loadcase	BSR-1P	BSR-2P	BSR-1S	BSR-2S	BSP-1P	BSP-2P	BSP-1S	BSP-2S
EDW	BSR				BSP			
Heading	Beam				Beam			
Effect	Max. roll				Max. pressure at waterline			
VWBM	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging
VWSF	Negative-aft Positive-fore	Positive-aft Negative-fore	Negative-aft Positive-fore	Positive-aft Negative-fore	Negative-aft Positive-fore	Positive-aft Negative-fore	Negative-aft Positive-fore	Positive-aft Negative-fore
HWBM	Stbd tensile	Port tensile	Port tensile	Stbd tensile	Stbd tensile	Port tensile	Port tensile	Stbd tensile
Surge	–	–	–	–	To bow	To stern	To bow	To stern
a_{surge}	–	–	–	–				
Sway	To starboard	To Portside	To Portside	To starboard	To Portside	To starboard	To starboard	To Portside
a_{sway}								
Heave	Down	Up	Down	Up	Down	Up	Down	Up
a_{heave}								
Roll	Portside down	Portside up	Starboard down	Starboard up	Portside up	Portside down	Starboard up	Starboard down
a_{roll}								
Pitch	Bow up	Bow down	Bow up	Bow down	Bow up	Bow down	Bow up	Bow down
a_{pitch}								

Note)
VWBM & VWSF : Vertical bending moment and shear force are to be taken as defined in **Pt. 3, Ch 3.**
HWBM : Horizontal bending moment is to be taken as defined in **(B)**
WS : Weather side, side of the ship exposed to the incoming waves.
LS : Lee side, sheltered side of the ship away from the incoming waves.

(b) The accelerations due to ship motion are follows;
Surge acceleration due to surge, in $\mathrm{m/s^2}$, is to be taken as:

$$a_{surge} = 0.25\ a_0\, g$$

Sway acceleration due to sway, in $\mathrm{m/s^2}$, is to be taken as:

$$a_{sway} = 0.55\ a_0\, g$$

Heave (vertical) acceleration due to heave, in $\mathrm{m/s^2}$, is to be taken as:

$$a_{heave} = a_0\, g$$

Table 9 Load combination factors, LCFs for BSR and BSP load cases

Load component		LCF	BSR-1P	BSR-2P	BSR-1S	BSR-2S	BSP-1P	BSP-2P	BSP-1S	BSP-2S
Hull girder loads	M_{wv}	C_{WV}	-0.1	0.1	-0.1	0.1	-0.4	0.4	-0.4	0.4
	Q_{wv}	C_{QW}	0.1	-0.1	0.1	-0.1	0.3	-0.3	0.3	-0.3
	M_{wh}	C_{WH}	0.4	-0.4	-0.4	0.4	0.4	-0.4	-0.4	0.4
Longitudinal accelerations	a_{surge}	C_{XS}	0.0	0.0	0.0	0.0	-0.15	0.15	-0.15	0.15
	$a_{pitch-x}$	C_{XP}	0.4	-0.4	0.4	-0.4	0.45	-0.45	0.45	-0.45
	$gsin\phi$	C_{XG}	-0.3	0.3	-0.3	0.3	-0.25	0.25	-0.25	0.25
Transverse accelerations	a_{sway}	C_{YS}	0.5	-0.5	-0.5	0.5	0.4	-0.4	-0.4	0.4
	a_{roll-y}	C_{YR}	1.0	-1.0	-1.0	1.0	1.0	-1.0	-1.0	1.0
	$gsin\theta$	C_{YG}	-1.0	1.0	1.0	-1.0	-0.9	0.9	0.9	-0.9
Vertical accelerations	a_{heave}	C_{ZH}	-0.25	0.25	-0.25	0.25	0.5	-0.5	0.5	-0.5
	a_{roll-z}	C_{ZR}	1.0	-1.0	1.0	-1.0	1.0	-1.0	-1.0	1.0
	$a_{pitch-z}$	C_{ZP}	0.4	-0.4	0.4	-0.4	0.45	-0.45	0.45	-0.45

Roll acceleration, a_{roll}, in $\mathrm{rad/s^2}$, is to be taken as:

$$a_{roll} = \theta \frac{\pi}{180}\left(\frac{2\pi}{T_\theta}\right)^2 .$$

Pitch acceleration, a_{pitch}, in $\mathrm{rad/s^2}$, is to be taken as:

$$a_{pitch} = 1.5\,\phi \frac{\pi}{180}\left(\frac{2\pi}{T_\phi}\right)^2$$

The accelerations used to derive the inertial loads at any position are defined with respect to the ship fixed coordinate system. Hence the acceleration values include the gravitational acceleration components due to the instantaneous roll angles.
The longitudinal acceleration at any position for each dynamic load case, in $\mathrm{m/s^2}$, is to be taken as:

$$a_X = -C_{XG}\, g \sin\phi + C_{XS} a_{surge} + C_{XP} a_{pitch}(z-R)$$

The transverse acceleration at any position for each dynamic load case, in $\mathrm{m/s^2}$, is to be taken as:

$$a_Y = C_{YG}\, g \sin\theta + C_{YS} a_{sway} - C_{YR}\, a_{roll}(z-R)$$

The vertical acceleration at any position for each dynamic load case, in $\mathrm{m/s^2}$, is to be taken as:

$$a_Z = C_{ZH} a_{heave} + C_{ZR}\, a_{roll}\, y - C_{ZP} a_{pitch}(x-0.45L)$$

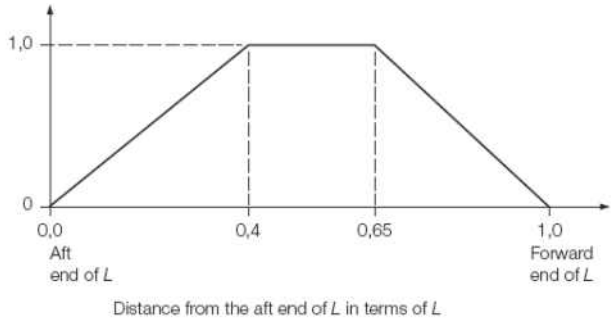
(c) Hull girder loads
The wave induced vertical bending moment and shear force are to be taken as defined in (G) and (H) in (4). The horizontal wave bending moment at any longitudinal position, in kNm, is to be taken as:

$$M_{wh} = f_{nlh}\left(0.31 + \frac{L}{2800}\right) f_m\, C_w\, L^2 T_{SC} C_B$$

where:

f_{nlh} : Coefficient considering nonlinear effect to be taken as: $f_{nlh} = 0.9$

f_m : Distribution factor is to be taken as;



C_w : Wave coefficient, in m, to be taken as:

$$C_w = 10.75 - \left(\frac{300 - L}{100}\right)^{1.5} \quad \text{for } 90 \le L \le 300$$

$$C_w = 10.75 \quad \text{for } 300 < L \le 350$$

$$C_w = 10.75 - \left(\frac{L - 350}{150}\right)^{1.5} \quad \text{for } 350 < L \le 500$$

(d) Hydrodynamic pressure for BSR load cases

The wave pressures, P_W, for BSR-1 and BSR-2 load cases, at any load point, in $\mathrm{kN/m^2}$, are to be obtained from **Table 10**, Fig 13 and 14. Total external pressure is to be calculated by $P_S + P_W$,, P_S means still water hydrostatic pressure for considered loading condition.

Table 10 Hydrodynamic pressures for BSR load cases

	Wave pressure, in $\mathrm{kN/m^2}$		
Load case	$z \le T_{SC}$	$T_{SC} < z \le h_W + T_{SC}$	$z > h_W + T_{SC}$
BSR-1P	$P_W = \max\,(P_{BSR},\, \rho g\,(z - T_{SC}))$	$P_W = P_{W,WL} - \rho g(z - T_{SC})$	$P_W = 0.0$
BSR-2P	$P_W = \max\,(-P_{BSR},\, \rho g\,(z - T_{SC}))$		
BSR-1S	$P_W = \max\,(P_{BSR},\, \rho g\,(z - T_{SC}))$		
BSR-2S	$P_W = \max\,(-P_{BSR},\, \rho g\,(z - T_{SC}))$		

where;

For BSR-1P and BSR-2P load cases:

$$P_{BSR} = f_\beta f_R f_{nl}\, k_a\, k_p \left[9\, y \sin\theta + (-0.95\, f_{yB} - 2 f_{zT} - 0.2)\, C_W \sqrt{\frac{L + \lambda - 125}{L}}\right]$$

For BSR-1S and BSR-2S load cases:

$$P_{BSR} = f_\beta f_R f_{nl} k_a k_p \left[-9 y \sin\theta + \left(-0.95 f_{yB} - 2 f_{zT} - 0.2 \right) C_W \sqrt{\frac{L+\lambda-125}{L}} \right]$$

f_R : Factor related to the operational profile, to be taken as : $f_R = 0.85$

f_{nl} : Coefficient considering non-linear effect, to be taken as :

$$f_{nl} = 1.0$$

$$k_a = k_{a-WL} f_{yB} + k_{a-CL} (1 - f_{yB})$$
$$k_p = k_{p-WL} f_{yB} + k_{p-CL} (1 - f_{yB})$$

Phase coefficient, k_{a-WL}, k_{a-CL}, k_{p-WL} and k_{p-CL} are to be taken as following; Intermediate values are to be interpolated.

- Port side of BSR-1P and BSR-2P or starboard side BSR-1S and BSR-2S

f_{xL}	0.0	0.2	0.35	0.5	0.7	1.0
k_{a-WL}	0.4	0.9	1.05	1.0	0.9	0.6

f_{xL}	0.0	0.15	0.3	0.6	0.85	1.0
k_{p-WL}	2.0	2.0	1.6	1.0	1.0	-1.0

- Port side of BSR-1S and BSR-2S or starboard side BSR-1P and BSR-2P

f_{xL}	0	0.3	0.5	0.65	0.8	1.0
k_{a-WL}	0.2	0.75	1.	1.1	1.0	0.8

f_{xL}	0.0	0.1	0.2	0.4	0.6	0.8	1.0
k_{p-WL}	0.95	0.9	0.7	1.0	1.0	0.9	1.0

- Center line

f_{xL}	0.0	0.2	0.4	0.6	0.85	1.0
k_{a-CL}	1.5	1.5	1.0	1.0	2.0	2.0

f_{xL}	0.0	0.2	0.5	0.7	1.0
k_{p-CL}	-0.5	-0.5	1.0	1.0	1.0

f_{xL} : Ratio between X-coordinate of the load point and L, to be taken as:

$f_{xL} = \frac{x}{L}$, but not to be taken less than 0.0 or greater than 1.0.

f_{zT} : Ratio between Z-coordinate of the load point and T_{SC}, to be taken as:

$f_{zT} = \frac{z}{T_{SC}}$, but not greater than 1.0.

f_{yB} : Ratio between Y-coordinate of the load point and B, to be taken as:

$f_{yB} = \frac{|2y|}{B_x}$, but not greater than 1.0.

$f_{yB} = 0$, when $B_x = 0$

B_x : Moulded breadth at the waterline, in m, at the considered cross section.

λ : Wave length of the BSR load case, in m, to be taken as:

$$\lambda = \frac{g}{2\pi} T_\theta^2$$

$P_{W,WL}$: Wave pressure at the waterline, $\mathrm{kN/m^2}$, for the considered dynamic load case. $P_{W,WL} = P_{BSR}$ for $y = B_x/2$ and $z = T_{SC}$

h_W : Water head equivalent to the pressure at waterline, in m, to be taken as:

$$h_w = \frac{P_{W,WL}}{\rho g}$$

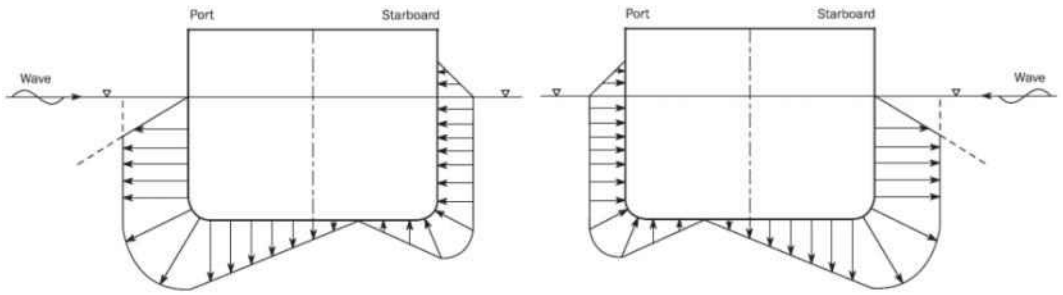


Fig 13 Transverse distribution of dynamic pressure for BSR-1S(left)와 BSR-1P(right) load cases

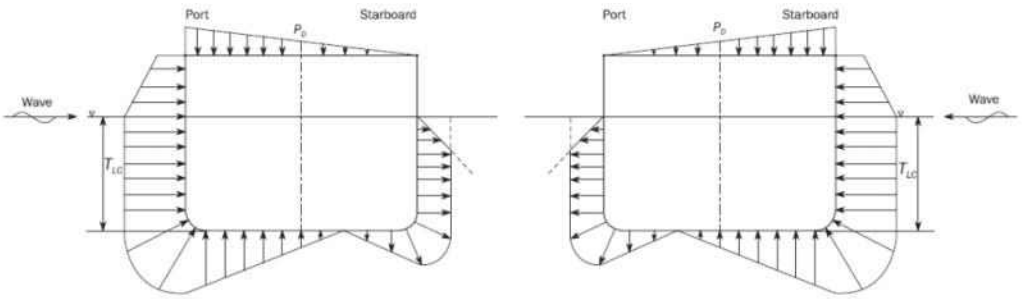


Fig 14 Transverse distribution of dynamic pressure for BSR-2S(left)와 BSR-2P(right) load cases

(e) Hydrodynamic pressure for BSP load cases

The wave pressures, P_W, for BSP-1 and BSP-2 load cases, at any load point, in $\mathrm{kN/m^2}$, are to be obtained from **Table 11, Fig 16** and **17.** Total external pressure is to be calculated by $P_S + P_W$, P_S means still water hydrostatic pressure for considered loading condition.

Table 11 Hydrodynamic pressures for BSP load cases

	Wave pressure, in kN/m^2		
Load case	$z \leq T_{SC}$	$T_{SC} < z \leq h_W + T_{SC}$	$z > h_W + T_{SC}$
BSP-1P	$P_W = \max(P_{BSP}, \rho g(z - T_{SC}))$	$P_W = P_{W,WL} - \rho g(z - T_{SC})$	$P_W = 0.0$
BSP-2P	$P_W = \max(-P_{BSP}, \rho g(z - T_{SC}))$		
BSP-1S	$P_W = \max(P_{BSP}, \rho g(z - T_{SC}))$		
BSP-2S	$P_W = \max(-P_{BSP}, \rho g(z - T_{SC}))$		

where;

$$P_{BSP} = 1.25 f_\beta f_R f_{nl} k_a k_p f_{yz} C_W \sqrt{\frac{L + \lambda - 125}{L}}$$

f_R : Factor related to the operational profile, is defined in (d)

f_{nl} : Coefficient considering non-linear effect, to be taken as :

- For extreme sea loads design load scenario :

$f_{nl} = 0.6$ at $f_{xL} = 0$
$f_{nl} = 0.8$ at $f_{xL} = 0.3$
$f_{nl} = 0.8$ at $f_{xL} = 0.7$
$f_{nl} = 0.6$ at $f_{xL} = 1$

Transverse Position	BSP-1P and BSP-2P	BSP-1S and BSP-2S
$y \geq 0$	$f_{yz} = 10\frac{z}{T_{SC}} + 8.5 f_{yB} + 0.1$	$f_{yz} = -1.3\frac{z}{T_{SC}} - 4 f_{yB} + 0.1$
$y < 0$	$f_{yz} = -1.3\frac{z}{T_{SC}} - 4 f_{yB} + 0.1$	$f_{yz} = 10\frac{z}{T_{SC}} + 8.5 f_{yB} + 0.1$

λ : Wave length of the BSP load case, in m, to be taken as:

$$\lambda = 0.5L$$

$$k_a = k_{a-WL} f_{yB} + k_{a-CL}(1 - f_{yB})$$
$$k_p = k_{p-WL} f_{yB} + k_{p-CL}(1 - f_{yB})$$

Phase coefficient, k_{a-WL}, k_{a-CL}, k_{p-WL} and k_{p-CL} are to be taken as following; Intermediate values are to be interpolated.

- Port side of BSP-1P and BSP-2P or starboard side BSP-1S and BSP-2S

f_{xL}	0.0	0.2	0.35	0.5	0.6	0.8	0.9	1
k_{a-WL}	0.3	0.9	1.1	1.0	0.9	0.9	0.7	0.5

f_{xL}	0.0	0.2	0.4	0.9	1.0
k_{p-WL}	1.0	0.9	1.0	1.0	0.5

- Port side of BSP-1S and BSP-2S or starboard side BSP-1P and BSP-2P

f_{xL}	0	0.1	0.2	0.3	0.5	0.7	0.8	1.0
k_{a-WL}	0.2	0.3	0.5	0.8	1.0	1.15	1.1	0.9

f_{xL}	0.0	0.05	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0
k_{p-WL}	0.5	1.2	-0.4	-0.1	0.6	1.0	0.9	0.3	0.8	1.0

- Center line

f_{xL}	0.0	0.2	0.4	0.6	0.85	1.0
k_{a-CL}	1.0	1.0	1.0	1.0	2.0	2.0

f_{xL}	0.0	0.35	0.5	0.8	1.0
k_{p-CL}	1.6	1.6	1.0	1.5	1.0

$P_{W,WL}$: Wave pressure at the waterline, $\mathrm{kN/m^2}$, for the considered dynamic load case. $P_{W,WL} = P_{BSP}$ for $y = B_x/2$ and $z = T_{SC}$

Other parametric symbols are defined in **(d)**.

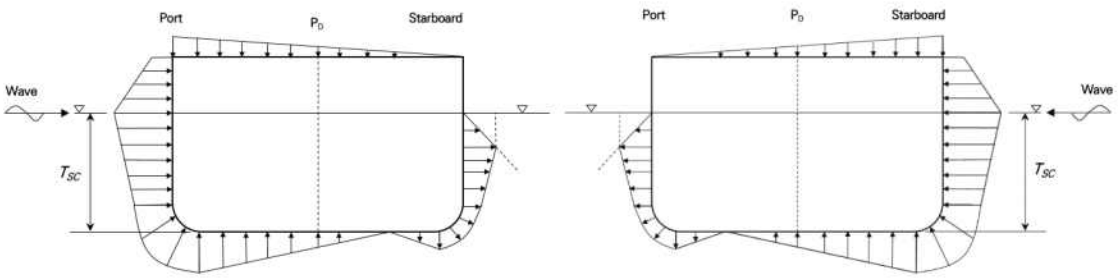


Figure 15 Transverse distribution of dynamic pressure for BSP-1P(left)와 BSP-1S(right) load cases

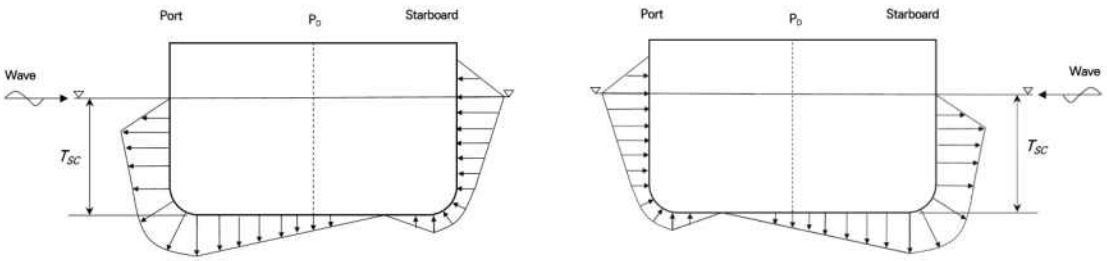


Figure 16 Transverse distribution of dynamic pressure for BSP-2P(left)와 BSP-2S(right) load cases

(f) Internal cargo loads

The cargo pressure due to ore cargo acting on any load point of a cargo hold boundary, in kN/m2, is to be taken as:

$$P_{in} = w + P_{bd}$$

Static pressure, w in kN/m2, due to ore cargo is defined in **(4), (A), (a) (ii)**. Dynamic pressure, P_{bd} in kN/m2, due to ore cargo for BSR load cases is to be taken as:

$$P_{bd} = f_\beta \gamma [0.25 a_x (x_G - x) + 0.25 a_y (y_G - y) + K_C a_z (z_C - z)] \quad (kN/m^2)$$
for $z < z_C$

$$P_{bd} = 0 \quad (kNm^2), \quad \text{for } z > z_C$$

where;

a_x, a_y, a_z : Longitudinal, transverse and vertical accelerations, in m/s2, at x_G, y_G, z_G.

x_G, y_G, z_G: X, Y and Z coordinates, in m, of the volumetric centre of gravity of fully filled cargo hold, i.e. V_{Full}, considered with respect to the reference coordinate system. In case of partially filled cargo hold, x_G, y_G, z_G to be taken as follows;

x_G, y_G : Volumetric centre of gravity of the cargo hold.
$z_G = h_{DB} + h_C/2$, h_{DB} and h_c are defined in **(4), (A), (a)**.

V_{Full} : Volume, in m^3, of cargo hold up to top of the hatch coaming, taken as:

$V_{Full} = V_H + V_{HC}$, V_H and V_{HC} are defined in **(4), (A), (a)**.

z_c : Height of the upper surface of the cargo above the baseline in way of the load point, in m, to be taken as:

$$z_c = h_{DB} + h_c$$

K_C : Coefficient is defined in **(4), (A), (a) (ii)**.

The shear load pressures, $P_{bs-s} + P_{bs-d}$, are to be considered for the hopper tank and the lower stool plating in addition to the ore cargo pressures when the load point elevation, z, is lower or equal to z_c. Static shear load, P_{bs-s}, due to gravitational forces acting on hopper tanks and lower stools plating, is defined as w_{sh} of **(4), (A), (a) (ii)**.

The dynamic shear load pressure, P_{bs-d} (positive downward to the plating) due to ore cargo forces on the hopper tank and lower stool plating, in kN/m2, is to be taken as:

$$P_{bs-d} = f_\beta \gamma a_z \frac{(1 - K_C)(z_C - z)}{\tan\beta}$$

Additionally, the dynamic shear load pressures, P_{bs-dx} and P_{bs-dy}, due to ore cargo forces acting along the inner bottom plating, in kN/m2, are to be taken as:

$P_{bs-dx} = -0.75 f_\beta \gamma a_x h_C$, in the longitudinal direction (positive to bow)

$P_{bs-dy} = -0.75 f_\beta \gamma a_y h_C$, in the transverse direction (positive to port)

(6) Allowable stresses

The stress calculated by the direct strength analysis using the dimension including the corrosion margin should meet the following criteria, and the evaluation range is shown in **Fig 17**.

$$\sigma_{act} < \sigma_{allow}$$

$$\sigma_{act} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau^2}$$

$$\sigma_{allow} = \eta\sigma_{yield}$$

$$\sigma_{yield} = 235/K(\mathrm{N/mm^2})$$

where;

η : Yield strength correction factor

$\eta = 0.9$: for longitudinal strength member of port condition and sea going condition defined in **(4)** and for all structural members of load conditions defined in (5).

$\eta = 0.72$: transverse strength member of port condition and sea going condition except load cases defined in **(5).**

K : Material factor (see **Pt.3 Annex 3-2** Table 5)

σ_x : Normal stress in x-direction of element coordinate system

σ_y : Normal stress in y-direction of element coordinate system\

τ : Shear stress on the face in x-y direction of element coordinate system

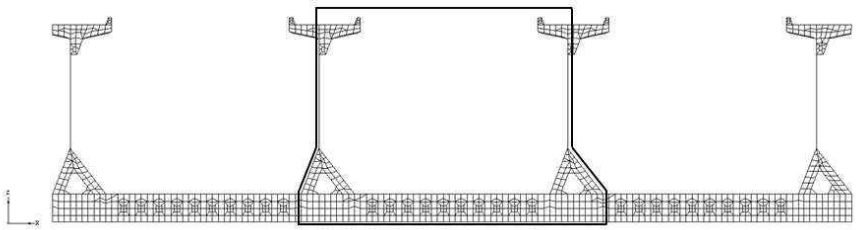


Fig 17 Evaluation range

(7) Buckling

The plate panel of hull structure is to be modelled as stiffened panel, SP or unstiffened panel, UP. Method A and Method B as defined in **Pt. 13, Sub-Pt 1, Ch. 8** are to be used according to Fig 18 to Fig 19. The detailed calculation of buckling strength is to be in accordance with **Pt. 13, Sub-Pt 1, Ch. 8. Sec 4 ~ 5** and the corrosion addition and judgments of buckling strength for buckling evaluation are as shown in Table 12 and 13. The 1.0 of buckling factor should be applied to all structural members for load cases to reflect dynamic shear loads in beam sea condition defined in (5).

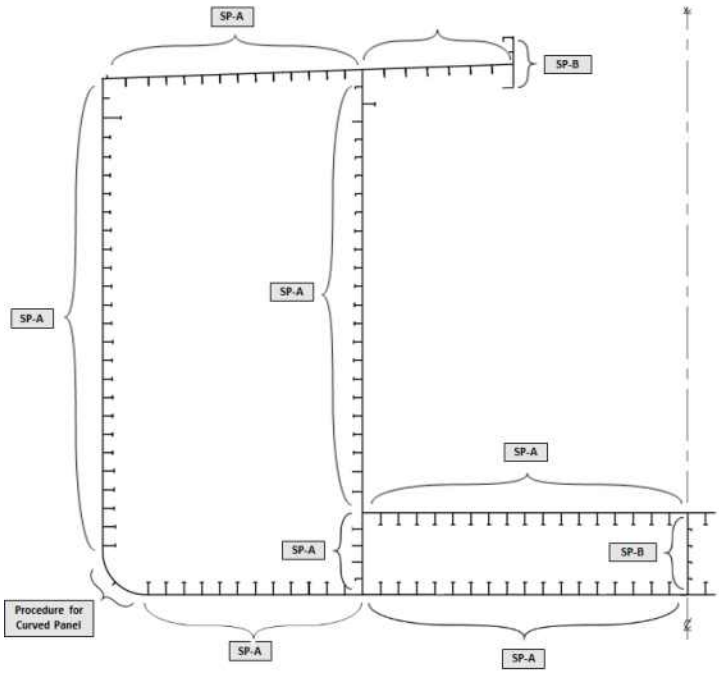


Fig 18 Longitudinal plate panel in VLOC

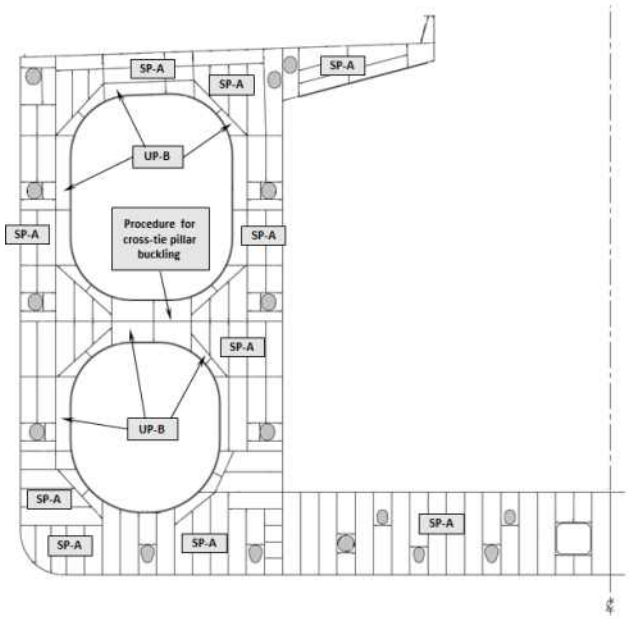


Fig 19 Plate panel of transverse web frame in VLOC

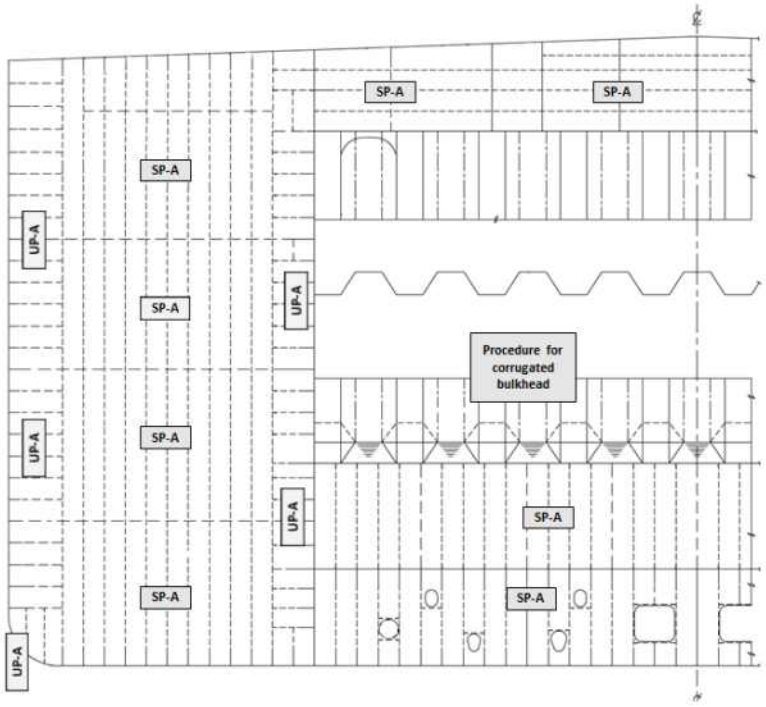


Fig 20 Plate panel of transverse bulkhead in VLOC

Table 12 Corrosion addition

Location	Corrosion addition
When both sides are in contact with seawater	2.5 mm
When one side is in contact with seawater	2.0 mm
When both sides are not in contact with seawater	1.5 mm

Table 13 Judgement of buckling strength

Member	Buckling factor
Cross Deck, Hatch End Beam and Upper Stool	0.8
Others	1.0

(8) Local fine mesh analysis
(A) Application
(a) The list of structural details of the fine mesh analysis are as follows.
- hopper knuckle
- openings
- connection between transverse bulkhead and longitudinal stiffener of deck and double bottom
- connection of corrugated bulkhead and the adjacent structure
- hatch corner

(b) For other high stress areas in which the stress (σ_{act}) calculated by direct strength analysis is greater than 95% of the allowable stress (σ_{allow}), additional analysis should be performed at the discretion of the Society.

(B) Fine mesh of the structure

(a) The range of the local fine mesh analysis should be at least 10 elements in all directions from the area under consideration.

(b) All plates and stiffeners within the local fine mesh analysis range should be represented by shell elements.

(c) For element corners, crooked elements less than 45 degrees or greater than 135 degrees should be avoided.

(d) The aspect ratio of the element should be kept as close as possible to 1, and should be less than 3.

(e) Mesh size of local fine mesh analysis should be such that it is capable of expressing the structure well and is less than the longitudinal spacing.

(f) When performing local fine mesh analysis for openings, the elements of the first two layers of the perimeter elements of the opening should be modeled to a size of 50 x 50 mm or less. End stiffeners directly welded to the opening end should be modeled as shell elements. The web stiffener near the opening is located at least 50 mm from the end of the opening and can be modeled using a rod or beam element.

(C) Allowable stress for local fine mesh analysis

(a) Allowable stresses for local fine mesh analysis should meet the following criteria.

$$\sigma_{act\_l} < \sigma_{allow\_l}$$

$$\sigma_{act\_l} = \sqrt{\sigma_{x\_l}^2 + \sigma_{y\_l}^2 - \sigma_{x\_l}\sigma_{y\_l} + 3\tau_l^2}$$

$$\sigma_{allow\_l} = \eta\eta_{local}\sigma_{yield\_l}$$

$$\sigma_{yield\_l} = 235/K \quad (\mathrm{N/mm^2})$$

where;

η : Yield strength correction factor as defined in **(6)**

η_{allow} : Local fine mesh analysis correction factor

$\eta_{allow} = 1.00$, element size ≤ longitudinal spacing (mm)

$\eta_{allow} = 1.15$, element size ≤ 200 x 200 (mm)

$\eta_{allow} = 1.25$, element size ≤ 100 x 100 (mm)

$\eta_{allow} = 1.50$, element size ≤ 50 x 50 (mm)

K : Material factor (see **Pt 3, Annex 3-2, Table 5**)

σ_{x_l}: Normal stress in x-direction of element coordinate system $(\mathrm{N/mm^2})$

σ_{y_l}: Normal stress in y-direction of element coordinate system $(\mathrm{N/mm^2})$

τ_l : Shear stress on the face in x-y direction of element coordinate system $(\mathrm{N/mm^2})$

(b) When evaluating the corner of the opening, the average stress can be evaluated as follows.(see **Fig 21**)

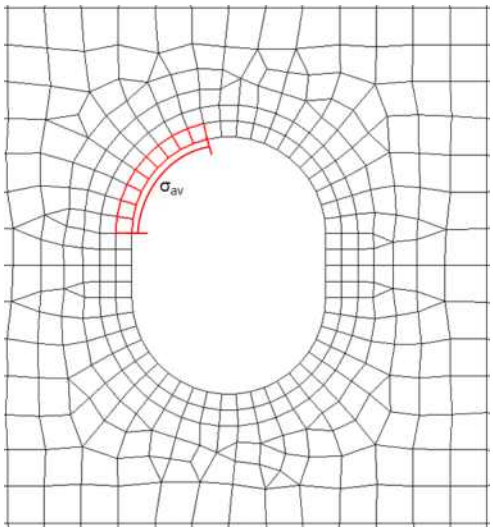


Fig 21 Opening

$$\sigma_{act} < \sigma_{allow}$$

where;

$$\sigma_{act} = \frac{\sum_{1}^{n} A_l \sigma_l}{\sum_{1}^{n} A_l}$$

σ_{allow} : Allowable stresses in direct strength analysis $(\mathrm{N/mm^2})$
σ_{act} : Mean stress in the considered range $(\mathrm{N/mm^2})$
σ_l : Each element stress in the considered range$(\mathrm{N/mm^2})$
A_l : Each element area in the considered range $(\mathrm{mm^2})$
n : Number of elements in the considered range

(9) Cargo Mass Curves

(A) The maximum and minimum drafts which are satisfied with maximum allowable cargo mass and the minimum required cargo mass for the each cargo hold are to be given by the following equations. In finite element analysis of middle cargo hold, holds No. 2 to n-1 are to be satisfied. The draft of fore end part is to be satisfied with maximum allowable cargo mass and the minimum required cargo mass of No. 1 cargo hold and the draft of aft end part is to be satisfied with maximum allowable cargo mass and the minimum required cargo mass of No. n cargo hold. (see **Fig 22**)

Maximum allowable cargo mass

Curve 1 : $W_{MAX,SEA}(T_{LC}) = M - 1.025LB(T_{MIN,SEA} - T_{LC})$ $(\leq M)$ (ton)

Curve 2 : $W_{MAX,HAR}(T_{LC}) = M - 1.025LB(T_{MIN,HAR} - T_{LC})$ $(\leq M)$ (ton)

Minimum required cargo mass

Curve 3 : $W_{MIN}(T_{LC}) = M - 1.025LB(T_{LC} - T_{multi-max})$ (ton)

Curve 4 : $W_{MIN,HAR}(T_{LC}) = 1.025LB(T_{LC} - T_{MAX,HAR})$ (≥ 0) (ton)

$W_{MAX,SEA}(T_{LC})$: Maximum allowable mass with draft, $\mathrm{T_{LC}}$ at sea going condition (ton)
$W_{MAX,HAR}(T_{LC})$: Maximum allowable mass with draft, $\mathrm{T_{LC}}$ at harbour (ton)

$W_{MIN,SEA}(T_{LC})$: Minimum required mass with draft, T_{LC} at sea going condition (ton)
$W_{MIN,HAR}(T_{LC})$: Minimum required mass with draft, T_{LC} at harbour (ton)
M : Maximum allowable mass of considered cargo hold (ton)
$T_{MIN,SEA}$: Minimum draft (m) at sea going condition which the maximum allowable cargo weight of the cargo hold is applied. But minimum draft at multi port condition subtracting 0.2m (considering the trim)
$T_{MAX,SEA}$: Maximum draft (m) at sea going condition which the minimum allowable cargo weight of the cargo hold is applied. But maximum draft at multi port condition including 0.2m (considering the trim)
$T_{MIN,HAR}$: Minimum draft (m) at the port state to which the maximum allowable cargo weight(M) of the cargo hold is applied. If the minimum draft in the port condition is not ascertained, an evaluation of the strength should be made by the following formula

$$T_{MIN,HAR} = T_{MIN,SEA} - (1.15M - W_{MAX,SEA}(T_{LC}))/(1.025LB)$$

L : length of the considered cargo hold (m)
B : mean breadth of the considered cargo hold (m)
$T_{MAX,HAR}$: Maximum draft (m) at port condition to which the minimum allowable cargo weight (M_{AD}) of cargo holds is applied

(B) The maximum and minimum drafts which are satisfied with maximum allowable cargo mass and the minimum required cargo mass for adjacent 2 cargo hold are to be given by the following equations. In finite element analysis of middle cargo hold, holds No. 2 and 3 to n-2 and n-1 are to be satisfied. The draft of fore end part is to be satisfied with maximum allowable cargo mass and the minimum required cargo mass of No. 1 and 2 cargo holds and the draft of aft end part are to be satisfied with maximum allowable cargo mass and the minimum required cargo mass of No. n-2 and n-1 cargo holds. (see **Fig 19**)

Maximum allowable cargo mass
Curve 1: $W_{MAX,SEA\_AD}(T_{LC}) = M_{AD} - 1.025L_{AD}B_{AD}(T_{MIN,SEA\_AD} - T_{LC})$ $(\leq M_{AD})$ (ton)
Curve 2: $W_{MAX,HAR\_AD}(T_{LC}) = M_{AD} - 1.025L_{AD}B_{AD}(T_{MIN,HAR\_AD} - T_{LC})$ $(\leq M_{AD})$ (ton)

Minimum required cargo mass
Curve 3: $W_{MIN,SEA\_AD}(T_{LC}) = 1.025L_{AD}B_{AD}(T_{LC} - T_{MAX,SEA\_AD})$ (≥ 0) (ton)
Curve 4: $W_{MIN,HAR\_AD}(T_{LC}) = 1.025L_{AD}B_{AD}(T_{LC} - T_{MAX,HAR\_AD})$ (≥ 0) (ton)

$W_{MAX,SEA\_AD}(T_{LC})$: Maximum allowable mass of adjacent 2 cargo holds with draft, T_{LC} at sea going condition (ton)
$W_{MAX,HAR\_AD}(T_{LC})$: Maximum allowable mass of adjacent 2 cargo holds with draft, T_{LC} at port (ton)
$W_{MIN,SEA\_AD}(T_{LC})$: Required cargo mass of adjacent 2 cargo holds with draft, T_{LC} at sea going condition (ton)
$W_{MIN,HAR\_AD}(T_{LC})$: Required cargo mass of adjacent 2 cargo holds with draft, T_{LC} at port (ton)
T_{MIN,SEA_AD} : Minimum draft (m) in the sea going condition to which the maximum allowable cargo weight (M_{AD}) of adjacent 2 cargo holds is applied
T_{MAX,SEA_AD} : Maximum draft (m) in the sea going condition to which the minimum allowable cargo weight (M_{AD}) of adjacent 2 cargo holds is applied
T_{MIN,HAR_AD} : Minimum draft (m) at the port state to which the maximum allowable

cargo weight(M_{AD}) of the cargo hold is applied. If the minimum draft in the port condition is not ascertained, an evaluation of the strength should be made by the following formula.

$$T_{MIN,HAR\_AD} = T_{MIN,SEA\_AD} - (1.15M_{AD} - W_{MAX,SEA\_AD}(T_{LC}))/(1.025L_{AD}B_{AD})$$

M_{AD} : Maximum allowable mass of adjacent 2 cargo holds (ton)
L_{AD} : length of the considered cargo holds (m)
B_{AD} : mean breadth of the considered cargo holds (m)
T_{MAX,HAR_AD} : Maximum draft (m) at port condition to which the minimum allowable cargo weight (M_{AD}) of adjacent 2 cargo holds is applied ⚓

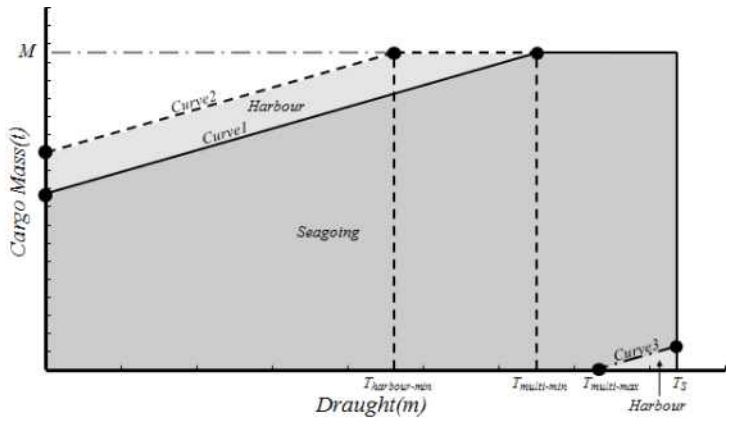


Fig 22 Cargo mass curves

Annex 7-11 Guidance on Providing Safe Working Conditions for Securing of Containers on Deck *(2019)*

1. General

(1) Objective

The objective of the additional special feature notation CSAP should provide safe working conditions in safe access and safe places of work, when they are worked in container securing operations on deck.

(2) Scope

The scope of the additional special feature notation CSAP should ensure safer working conditions in container securing operations. This guidelines describe requirements covering design and arrangement of working areas, container top working, fencing and fall protection, marking of obstacles and openings, design of walkways, ladders, steps and other means of access, design and arrangement of power supplies for reefer containers and lightings of working and transit areas.

(3) Application

Ships complying with this guidelines will be assigned the additional special feature notation CSAP. The additional special feature notation CSAP is applicable to ships designed for carrying containers on deck. The additional special feature notation CSAP can be applied to other ships upon request.

(4) Definitions

(A) Definitions used in this guidelines are given as following.

- working area : any positions or spaces used for operating container securing devices, e.g. in between container stows on hatch covers; lashing bridges and platforms
- transit area : passage ways, stairs, decks and other areas used for moving about the ship
- fencing : a generic term for guardrails, safety rails, safety barriers and similar structures that provide protection against the falls of people
- stringers : the uprights or sides of a ladder
- rungs : the bars that form the steps of a ladder

2. Documentation

(1) CSAP should be submitted for approval and includes following.

- Arrangement and detail of working area and transit area
- Lighting arrangement and illumination in working and transit area
- Location and detail of reefer container power outlet and adjacent working area

3. Design requirements

(1) General

(A) The cargo safe access plan should be developed at the design stage to ensure that securing operations can be carried out safely for all intended container stowage configurations.

(B) Typically the cargo safe access plan should be developed based on a risk assessment including following hazards:

- slips, trips,
- falls from height,
- injuries whilst manually handling lashing gear,
- being struck by lashing gear or other objects,
- potential damage due to container operations(High-risk areas should be identified in order to develop appropriate protection or other methods of preventing significant damage),
- adjacent electrical risks (temperature controlled unit cable connections etc.),
- adequate access to all areas that is necessary to safely perform container securing operations
- ergonomics (e.g., size and weight of equipment) of lashing equipment,
- implications of lashing high cube (9'6") containers and mixed stows of 40' and 45' containers.

(2) Transit area

(A) The minimum clearance for transit areas should be at least 2.0 m high and 600 mm wide. (Table 1 B, J and F1)

(B) Transit area should have non-slip surfaces.

(C) Where necessary for safety, walkways on deck should be delineated by painted lines or otherwise marked by pictorial signs.
(D) All protrusions in access ways in transit area, such as cleats, ribs and brackets that may give rise to a trip hazard, should be highlighted in a contrasting colour.
(E) As far as practicable, access ladders and walkways should be free of permanent obstructions and designed so that workers do not have to climb over piping.

(3) Working area
(A) Working areas should be designed to eliminate the use of three high lashing bars and be positioned in close proximity to lashing equipment stowage areas.
(B) Working areas should be designed to provide a clear work area which is unencumbered by obstructions such as deck piping, storage bins and guides to reposition hatch covers.
(C) The horizontal distance from the lashing securing points to the containers should not exceed 1,100 mm, and not less than 220 mm for lashing bridges and 130 mm for other positions. (Table 1, C1, C2 and C3.) For container bays with foundations designed for 40' and 45' container stowage, the dimension C1 may be increased to 1,300 mm when measured to 40' containers depending on the approval of Flag state.
(D) The width of working areas should not be less than 750 mm. In addition, the width of permanent lashing bridges should not be less than 750 mm between top rails of fencing and should provide a minimum clear distance of 600 mm between stowage racks, lashing cleats and other obstructions. (Table 1, A, GL, GT, I, F and F1.)
(E) Platforms should be provided on the end of hatches and outboard lashing positions. Platforms on the end of hatches and outboard lashing positions should preferably be at the same level as the top of the hatch covers. The gap between such platforms and adjacent hatch covers should not exceed 90 mm.
(F) Working areas which contain removable sections should be capable of being temporarily secured.
(G) Working on the top of containers should be avoided, e.g. through use of semi-automatic or fully automatic twistlocks.
(H) Toe boards of 150 mm in height should be provided around the sides of elevated working areas, to prevent securing equipment from falling and injuring people. In cases where toe board obstructs the stowage of containers, the height of toe board may be reduced to 100 mm.

(4) Fencing design
(A) Lashing bridges, platforms and other working area from which persons may fall should be provided with fencing satisfying the requirements given in (D). *(2020)*
(B) If necessary, a mobile fencing may be allowed.
(C) Athwartships cargo securing walkways should be protected by fencing satisfying the requirements given in (D), if the edges of walkways are not protected when the hatch cover is removed.
(D) Fencing should have a minimum of three courses. The height of the uppermost course should be at least 1.0 m, measured from the base. The opening below the lowest course of the guardrails should not exceed 230 mm. The other courses should not be more than 380 mm apart. A horizontal unfenced gap of fencing should not be greater than 300 mm.
(E) At positions where movable fencings are arranged due to stowage of containers, e.g., lashing platform above outboard stanchions at 20' container gap end, see Fig 3 for illustration, an alternative arrangement of the lower two courses may be accepted by the Society, as necessary, taking position of container securing device into consideration.

(5) Access openings
(A) Access openings in working area with a potential should be either protected by fencing in accordance with (4)(D) or possible to be closed by access covers. *(2020)*
(B) Access openings in transit area with a potential fall of 2.0 m or more should be avoided, unless they are protected by fencing in accordance with (4)(D).
(C) Access openings in working area and transit area should be highlighted in contrasting colour around the rim of the openings.
(D) Access openings at different levels of lashing bridges should not be located directly below one another.

(6) Ladders
(A) Where a fixed ladder gives access to the outside boundary of a working area, the stringers should be connected at their extremities to the guardrails of the working area, irrespective of whether the ladder is sloping or vertical. The stringers of shell also be opened above the working area level to give a minimum clear width of 700 mm to enable a person to pass through the stringers.
(B) Where a fixed ladder gives access to a working area through an opening in the working area, handholds extending at least 1.0 m above the working area should be provided, to ensure safe access through the opening.
(C) A fixed ladders should not slope at angle greater than 25° from vertical. Where the slope of a ladder exceeds 15° from vertical, the ladder should be provided with suitable handrails positioned not less than 540 mm from the stringers, measured horizontally.
(D) A fixed ladders should provide a foothold at least 150 mm deep.
(E) A fixed ladders with a vertical height exceeding 3.0 m, and any fixed ladders, from which a person may fall into a hold, should be fitted with a guard hoops satisfying the requirements given in (F) to (G).
(F) The distance between the rungs and the back of the safety cage should be min. 750 mm. Safety cage hoops should be uniformly spaced at intervals not exceeding 900 mm and be connected by vertical bars inside the hoop uniformly spaced around the circumference of the hoops.
(G) The stringers should be extended at least 1.0 m above the working area, and the ends of the stringers should be given lateral support. The top step or rung should be at the same level of the working area.

(7) Container securing equipment arrangement
(A) The lashing rod's length in conjunction with the length and design of the turnbuckle should be such that the need of extension is eliminated when lashing high cube (9'6") containers. In the container securing arrangement document, typical lashing patterns for 9'6" containers should be shown, if such containers are stowed on board.
(B) During tightening or loosening motions on turnbuckles, the risk for hand injury should be minimised, e.g., by keeping sufficient distance between turnbuckles. During tightening or loosening motions, the distance between turnbuckles is typically not less than 70mm. *(2020)*
(C) Storage bins should be provided for container securing equipment

(8) Power supply
(A) Reefer power outlets should provide a safe, watertight electrical connection.
(B) Reefers should feature a heavy-duty, interlocked and circuit-breaker protected electrical power outlets. This should ensure the outlet can not be switched on until a plug is fully engaged and the actuator rod is pushed to the "ON" position. Pulling the actuator rod to the "OFF" position should manually de-energize the circuit.
(C) Reefer power outlets should de-energize automatically if the plug is accidentally withdrawn while in the "On" position. Also, the interlock mechanism should break the circuit while the pin and sleeve contacts are still engaged.
(D) Reefer power outlets should be positioned and designed so as not to require the operator to stand directly in front of the socket when switching takes place.
(E) The positioning of reefer power outlets should not be such that the flexible cabling needs to be laid out in such a way as to cause a tripping hazard.

(9) Lighting
(A) Working areas and transit areas should be provided with lighting.
(B) The lighting should be designed as a permanent installation adequately guarded against breakage. Temporary lighting may be accepted by the Society, as necessary, basis at locations where permanent lighting is not practical.
(C) Light intensity levels should not be less than 10 lux for transit area and 50lux for working area.

Table 1 Working and transit area dimension

Dimension (see Fig)	Description	Requirement (mm)
A	Width of work area between container stacks (**Fig 1**)	min. 750
B	Distance between lashing plates on deck or on hatch covers (**Fig 1**)	min. 600
C1	Distance from lashing bridge fencing to container stack (**Fig 2**)	max 1,100*
C2	Distance from lashing plate to container stack (lashing bridge) (**Fig 2**)	min. 220
C3	Distance from lashing plate to container stack (elsewhere) (**Fig 1**)	min. 130
F	Width of lashing bridge between top rails of fencing (**Fig 2**)	min. 750
F1	Width of lashing bridge between storage racks, lashing cleats and any other obstruction (**Fig 2**)	min. 600
GL	Width of working platform for outboard lashing - fore/aft (**Fig 3**)	min. 750
GT	Width of working platform for outboard lashing - transverse (**Fig 3**)	min. 750
I	Width of work platform at end of hatch cover or adjacent to super-structure (**Fig 4**)	min. 750
J	Distance from edge of hatch cover to fencing (**Fig 4**)	min. 600
K	Width of lashing bridge between top rails of fencing (**Fig 2**)	min. 750
K1	Width of lashing bridge between the pillars of the lashing bridge (**Fig 2**)	min. 600

(Notes)

B	Measured between the centers of the lashing plates.
C1	Measured from inside of fencing.
C2, C3	Measured from center of lashing plate to end of container.
F, K	Measured to inside of fencing.
GL	Measured from end of container to inside of fencing.
GT	Measured to inside of fencing.
I	Measured to inside of fencing.
J	Measured to inside of fencing.
*	may be increased to 1,300mm depending on the approval of Flag state.

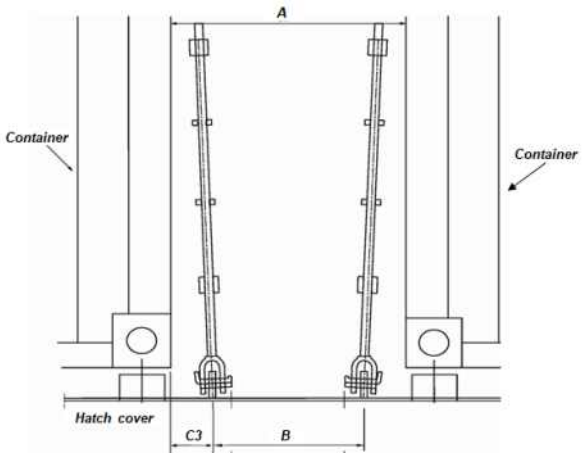


Fig 1 Work area between container stacks

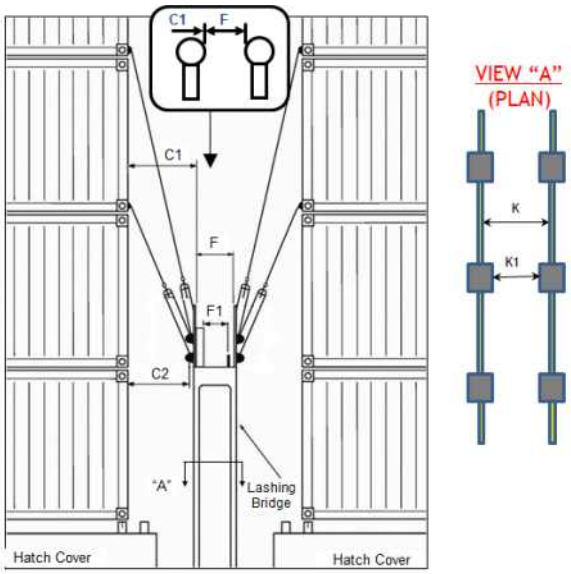


Fig 2 Lashing bridge

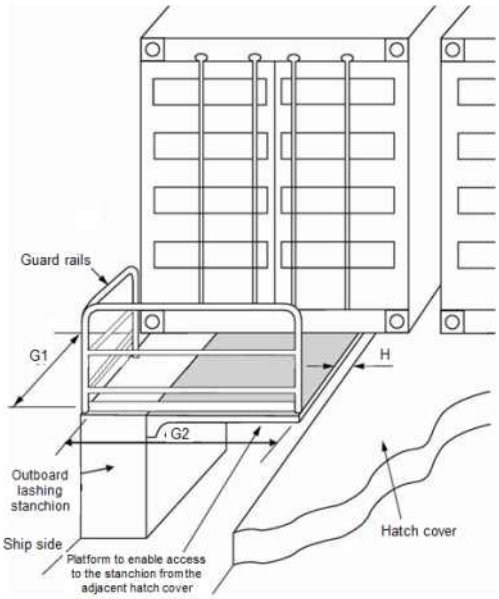


Fig 3 Lashing platforms on outboard stanchions

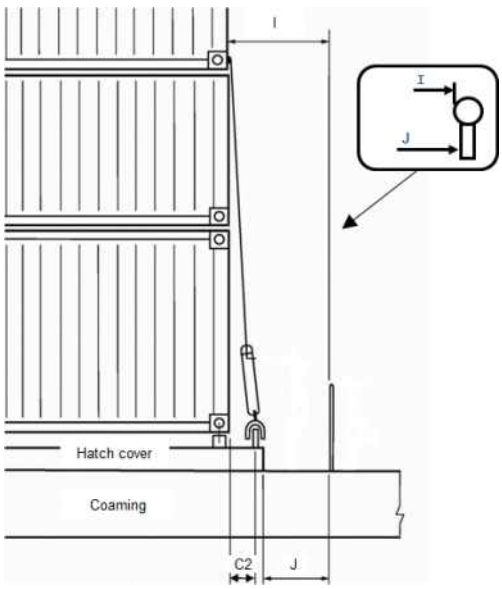


Fig 4 Work area between hatch covers

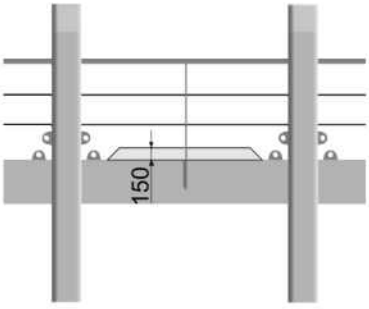


Fig 3 Toe boards

Rules for the Classification of Steel Ships
Guidance Relating to the Rules for the Classification of Steel Ships

PART 7 SHIPS OF SPECIAL SERVICE

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