Contents

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CS HULL CONSTRUCTION AND EQUIPMENT OF SMALL SHIPS

Chapter 1 GENERAL

1.1 Application and Equivalency

1.1.1 Application*

1 This part applies to steel ships of normal form and proportions of less than 90 *m* in length to be classed for unrestricted service.

2 Hull construction, equipment and scantlings of ships to be classed for restricted service may be appropriately modified according to the condition of service in addition to the requirements in **Chapter 27**.

3 In the application of relevant provisions in this Part to ships to which the requirements in **Part V** do not apply, L_f is to be read as L and B_f as B.

4 Cargo vessels engaged in international voyages and that are not less than 500 gross tonnage are to comply with the requirements in **2.3.4, Part 1, Part C**.

Note: For the construction of ships flying the Japanese flag, alternative arrangements are to be made.

5 Where deemed necessary by the Society, ships coming under the definition of bulk carrier as specified in **An1.2.1(1), Annex 1.1, Part 2-2, Part C**, may be applicable to relevant requirements of **Part C**.

1.1.2 Special Cases in Application

Notwithstanding the provisions in **1.1.1**, the requirements for hull construction, equipment, arrangement and scantlings of ships less than 30 *m* in length or that do not comply with the requirements in this Part for some special reason are to be at the Society's discretion.

1.1.3 Ships of Unusual Form or Proportion, or Intended for Carriage of Special Cargoes

1 In ships of unusual form or proportion, or intended for carriage of special cargoes, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of this Part instead of the requirements in this Part.

2 The hull structural members of ships intended for the carriage of cargoes having moisture contents which exceed transportable moisture limit are to be in accordance with the requirements provided in this Part. In addition, the special considerations deemed necessary by the Society are to be taken into account.

1.1.4 Equivalency

Alternative hull construction, equipment, arrangement and scantlings will be accepted by the Society, provided that the Society is satisfied that such construction, equipment, arrangement and scantlings are equivalent to those required in this Part.

1.2 General

1.2.1 (Deleted)

(Deleted)

1.2.2 Stability

The requirements in this Part apply to ships having appropriate stability in all conceivable conditions. The Society emphasizes that special attention is to be paid to ship stability by the builders during design and construction stages and by the masters while in service.

1.2.3 Fire-proof Construction and Means of Escape

Fire-proof construction and means of escape are to be in accordance with the requirements in **Part R**.

1.2.4 (Deleted)

(Deleted)

1.2.5 Docking

It is recommended that every ship be dry docked within six months after launching.

1.3 Materials, Scantlings, Welding and End Connections

1.3.1 Materials

1 The requirements in this Part concerning hull construction and equipment are based upon the use of materials which comply with the requirements in **Part K**.

2 Where high tensile steels specified in **Chapter 3, Part K**, are used, the construction and scantlings of ships are to comply with **(1)** to **(3)**:

(1) The section modulus of the transverse sections of the hull is not to be less than the value obtained by multiplying the following coefficient to the value specified in **Chapter 15**. Moreover, the extent of high tensile steel use is to be in accordance with the discretion of the Society.

: 0.78: where high tensile steels *KA32, KD32, KE32* and *KF32* are used

: 0.72: where high tensile steels *KA36, KD36, KE36* and *KF36* are used

: 0.68: where high tensile steels *KA40, KD40, KE40* and *KF40* are used (However, 0.66 may be taken where a fatigue assessment of the structure is performed to verify compliance with the requirements of the Society.)

(2) With the exception of the requirements in **(1)**, details such as the thickness of decks and shell plating, the section modulus of stiffeners, and other scantlings are to be at the discretion of the Society.

(3) With the exception of the requirements in **(1)**, the construction and scantlings where high tensile steels are used are to be at the discretion of Society.

3 Where materials other than those specified in **Part K** are used for the main hull structure, the use of such materials and corresponding scantlings are to be at the discretion of the Society.

4 Where stainless steel or stainless clad steel specified in **Chapter 3, Part K of the Rules** is used for the main hull structure, use of the materials and their scantlings are to be subject to the following.

(1) The section modulus of the transverse section of the hull is not to be less than the value obtained by multiplying the following coefficient (K) with the value specified in **Chapter 15**. However, the coefficient (K) is to be rounded to three decimal places and not less than 0.63.

$$K = f_T\{8.81(\sigma_y / 1000)^2 - 7.56(\sigma_y / 1000) + 2.29\} \text{ for } \sigma_y \leq 355 \ (N/mm^2)$$

$$K = f_T f_C(235 / \sigma_y) \text{ for stainless steel with } \sigma_y > 355 \ (N/mm^2)$$

Where

f_C: Determined as follows:

$$f_C = 3.04(\sigma_y / 1000)^2 - 1.09(\sigma_y / 1000) + 1.09$$

σ_y: The minimum value of yield strength (N/mm^2) or proof stress (N/mm^2) of stainless steel or stainless clad steel specified in **Chapter 3, Part K of the Rules**

f_T: Determined as follows:

$$f_T = 0.0025(T - 60) + 1.00$$

If T is more than 100°C, the value is at the discretion of the Society.

T: The maximum temperature (°C) of cargo in contact with the materials

Where the temperature is less than 60°C, T is to be taken as 60°C.

(2) Where the materials used acts effectively for corrosion resistance to cargoes intended to be carried, the value deemed appropriate by the Society may be reduced from the scantlings required by the relevant requirements.

(3) Notwithstanding the requirements in **(1)** above, 0.78 is to be used as the lower limit of the coefficient (K) when determining the

construction and scantlings for areas of anticipated stress concentration, except where deemed appropriate by the Society.

5 Where materials other than those specified in the Rules are used, the use of such materials and corresponding scantlings are to be specially approved by the Society.

6 Materials used for the hull construction of ships classed for *Smooth Water Service* are to be at the discretion of the Society.

7 The steels used for hull structures are to be in accordance with the requirements of **3.2.2, Part 1, Part C**. However, the steel grades shown in **Table CS1.1** and **Table CS1.2** may be used in lieu of **Table 3.2.2-1** and **Table 3.2.2-2, Part 1, Part C**. Where stainless clad steel specified in **Chapter 3, Part K of the Rules** is used for hull construction, the thickness of the base steel is to be used as the thickness of the plate in **Table 3.2.2-1** and **Table 3.2.2-2, Part 1, Part C**.

8 Use of the aluminium alloys specified in **Chapter 8, Part K of the Rules** is subject to the following.

(1) The proof stress (N/mm^2) used in this part is not to be less than the minimum ultimate proof stress specified for the base metal except when specified in **Table CS1.3**.

(2) The section modulus of the transverse section of the hull is not to be less than the value obtained by multiplying the following coefficient (K) with the value specified in **Chapter 15**.

$$K = \frac{235}{\sigma_{min.}}$$

where

$\sigma_{min.}$: determined as follows

for 5000 series aluminium alloys of O or $H111$: the minimum ultimate proof stress specified for the base metal (N/mm^2)

for 5000 series aluminium alloys other than O or $H111$ and 6000 series aluminium alloys: the proof stress specified in **Table CS1.3** (N/mm^2)

(3) With the exception of the requirements in **(2)** above, the construction and scantlings are to be at the discretion of the Society.

Table CS1.1 Application of Mild Steels for Various Structural Members

<table>
<tr><th rowspan="2">Structural member</th><th rowspan="2" colspan="2">Application</th><th colspan="6">Thickness of plate : $t(mm)$</th></tr>
<tr><th>$t \leqq 15$</th><th>$15 < t \leqq 20$</th><th>$20 < t \leqq 25$</th><th>$25 < t \leqq 30$</th><th>$30 < t \leqq 40$</th><th>$40 < t \leqq 50$</th></tr>
<tr><td colspan="9">Shell plating</td></tr>
<tr><td rowspan="3">Sheer strake at strength deck</td><td colspan="2">within $0.4L$ amidship</td><td>A</td><td>B</td><td colspan="2">D</td><td colspan="2">E</td></tr>
<tr><td colspan="2">within $0.6L$ amidship excluding the above</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td rowspan="2">Side plating</td><td rowspan="2">within $0.4L$ amidship</td><td>within $0.1D$ downward from the lower surface of strength deck</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td>other than those mentioned above</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td rowspan="2">Bilge strake</td><td colspan="2">within $0.6L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td>Bottom plating including keel plate</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="9">Deck plating</td></tr>
<tr><td rowspan="3">Stringer plate in strength deck</td><td colspan="2">within $0.4L$ amidship</td><td>A</td><td>B</td><td colspan="2">D</td><td colspan="2">E</td></tr>
<tr><td colspan="2">within $0.6L$ amidship excluding the above</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td rowspan="3">Strength deck strake adjoining to longitudinal bulkhead</td><td colspan="2">within $0.4L$ amidship</td><td>A</td><td>B</td><td colspan="2">D</td><td colspan="2">E</td></tr>
<tr><td colspan="2">within $0.6L$ amidship excluding the above</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td rowspan="2">Strength deck at cargo hatch corner</td><td colspan="2">within $0.4L$ amidship</td><td>A</td><td>B</td><td colspan="2">D</td><td colspan="2">E</td></tr>
<tr><td colspan="2">other than those mentioned above (requirements for large hatch openings are to be as given in the row above)</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td>Strength deck other than mentioned above</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td>Deck plating exposed to weather, in general</td><td colspan="2">within $0.4L$ amidship</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td colspan="9">Longitudinal bulkhead</td></tr>
<tr><td>Upper strake in longitudinal bulkhead adjoining to strength deck</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td>Lower strake in longitudinal bulkhead adjoining to bottom plate</td><td colspan="2">within $0.4L$ amidship</td><td colspan="4">A</td><td>B</td><td>D</td></tr>
<tr><td colspan="9">Longitudinals</td></tr>
<tr><td>Upper strake in sloping plate of topside tank adjoining to strength deck</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td>Longitudinal plating members above strength deck including end bracket and face plate of longitudinal girders</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
<tr><td colspan="9">Cargo Hatch</td></tr>
<tr><td>Cargo hatch coaming longitudinally extended on the strength deck over $0.15L$ (including face plate and its flange, but excluding other stiffeners)</td><td colspan="2">within $0.4L$ amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
</table>

Structural member	Application	Thickness of plate : $t(mm)$					
		$t \leqq 15$	$15 < t \leqq 20$	$20 < t \leqq 25$	$25 < t \leqq 30$	$30 < t \leqq 40$	$40 < t \leqq 50$
Hatch cover	top plates, bottom plates and primary supporting members	*A*				*B*	*D*
Stern							
Stern frame, rudder horn, rudder trunk, shaft bracket	—	*A*				*B*	*D*
Rudder							
Rudder Plate	—	*A*				*B*	*D*
Other							
Other members than those mentioned above (including stiffeners)		*A*					

(Notes)

1. *A*, *B*, *D*, *E* refer to the following grades of steel:
   A: *KA* *B*: *KB* *D*: *KD* *E*: *KE*
2. Where the strength deck strake adjoined to the inner skin bulkhead of double hull ships is not a deck stringer plate, the deck strake may be treated as an ordinary strength deck strake.

Table CS1.2 Application of High Tensile Steels for Various Structural Members

<table>
<tr><th rowspan="2">Structural member</th><th rowspan="2" colspan="2">Application</th><th colspan="6">Thickness of plate : $t(mm)$</th></tr>
<tr><th>$t≦15$</th><th>$15<t≦20$</th><th>$20<t≦25$</th><th>$25<t≦30$</th><th>$30<t≦40$</th><th>$40<t≦50$</th></tr>
<tr><td colspan="9">Shell plating</td></tr>
<tr><td rowspan="3">Sheer strake at strength deck</td><td colspan="2">within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td colspan="2">within 0.6L amidship excluding the above</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td rowspan="2">Side plating</td><td rowspan="2">within 0.4L amidship</td><td>within 0.1D downward from the lower surface of strength deck</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>other than those mentioned above</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td rowspan="2">Bilge strake</td><td colspan="2">within 0.6L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td>Bottom plating including keel plate</td><td colspan="2">within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td colspan="9">Deck plating</td></tr>
<tr><td rowspan="3">Stringer plate in strength deck</td><td colspan="2">within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
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<tr><td colspan="2">other than those mentioned above</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td rowspan="3">Strength deck strake adjoining to longitudinal bulkhead</td><td colspan="2">within 0.4L amidship to longitudinal bulkhead</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td colspan="2">within 0.6L amidship to longitudinal bulkhead</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td colspan="2">other than those mentioned above</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td rowspan="2">Strength deck at cargo hatch corner</td><td colspan="2">within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td colspan="2">other than those mentioned above (requirements for large hatch openings are to be as given in the row above)</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td>Strength deck other than mentioned above</td><td colspan="2">within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>Deck plating exposed to weather, in general</td><td colspan="2">within 0.4L amidship</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="9">Longitudinal bulkhead</td></tr>
<tr><td>Upper strake in longitudinal bulkhead adjoining to strength deck</td><td colspan="2">within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>Lower strake in longitudinal bulkhead adjoining to bottom plate</td><td colspan="2">within 0.4L amidship</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="9">Longitudinals</td></tr>
<tr><td>Upper strake in sloping plate of topside tank adjoining to strength deck</td><td colspan="2">within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>Longitudinal plating members above strength deck including end bracket and face plate of longitudinal girders</td><td colspan="2">within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
</table>

Structural member	Application	Thickness of plate : *t*(*mm*)					
		t≦15	15 <*t* ≦20	20<*t* ≦25	25<*t* ≦30	30<*t* ≦40	40<*t* ≦50
Cargo Hatch							
Cargo hatch coaming longitudinally extended on the strength deck over 0.15*L* (including face plate and its flange, but excluding other stiffeners)	within 0.4*L* amidship	*AH*			*DH*		*EH*
Hatch cover	top plates, bottom plates and primary supporting members	*AH*					*DH*
Stern							
Stern frame, rudder horn, rudder trunk, shaft bracket	—	*AH*					*DH*
Rudder							
Rudder Plate	—	*AH*					*DH*
Other							
Other members than those mentioned above (including stiffeners)		*AH*					

(Notes)

1. *AH*, *DH*, *EH* refer to the following grades of steel:
   AH : *KA*32, *KA*36 and *KA*40 *DH* : *KD*32, *KD*36 and *KD*40 *EH* : *KE*32, *KE*36 and *KE*40
2. Where the strength deck strake adjoined to the inner skin bulkhead of double hull ships is not a deck stringer plate, the deck strake may be treated as an ordinary strength deck strake.

Table CS1.3 Grades and Proof Stresses of Aluminium Alloys for Hull Structures

Grade and symbol of aluminium alloy		Temper condition	Thickness *t* (*mm*)	Proof stress (N/mm^2)
5000 series	5083*P*	*H*116, *H*321	*t*≤50	125 min.
	5383*P*	*H*116, *H*321	*t*≤50	145 min.
	5059*P*	*H*116, *H*321	*t*≤50	160 min.
	5086*P*	*H*112, *H*116	*t*≤50	95 min.
	5456*P*	*H*116, *H*321	*t*≤6.3	130 min.
			6.3<*t*≤50	125 min.
	5083*S*	*H*111	*t*≤50	110 min.
	5383*S*	*H*112	*t*≤50	145 min.
	5086*S*	*H*111	*t*≤50	95 min.
6000 series	6005*AS*	*T*5, *T*6	*t*≤50	115 min.
	6061*P*	*T*6	*t*≤6.5	115 min.
	6061*S*	*T*6	*t*≤50	115 min.
	6082*S*	*T*5, *T*6	*t*≤50	115 min.

1.3.2 Scantlings

1 Section moduli specified by the Rules include the steel plates with an effective breadth of 0.1 *l* on either side of the members, unless specified otherwise. However, the 0.1 *l* steel plates are not to exceed one-half of the distance to the next member. *l* is the length of the member specified in the relevant Chapters.

2 Where flat bars, angles or flanged plates are welded to form beams, frames or stiffeners for which section moduli are specified, they are to be of suitable depth and thickness in proportion to the section modulus specified in these Rules.

3 The inside radius of flanged plates is not to be less than twice but not more than three times the thickness of steel plates.

4 The thickness of face plates composing girders and transverses is not to be less than that of web plates and the full width is not to be less than that obtained from the following formula:

$85.4\sqrt{d_0 l}$ (mm)

d_0: Depth (m) of girders and transverses specified in the relevant Chapter

l: Distance (m) between supports of girders and transverses specified in the relevant Chapters
However, where effective tripping brackets are provided, they may be taken as supports.

5 Scantlings of stiffeners based on requirements in this Part may be decided based on the concept of grouping designated sequentially placed stiffeners of equal scantlings. The scantling of the group is to be taken as the greater of the values obtained from the following requirements **(1)** and **(2)**. However, this requirement is not applicable to fatigue requirements.

(1) the average of the required scantling of all stiffeners within a group

(2) 90% of the maximum scantling required for any one stiffener within the group

1.3.3 Welding

Welding to be used in hull construction and important equipment is to be in accordance with the requirements in **Chapter 12, Part 1, Part C** and **Part M**.

1.3.4 Connection of Ends of Stiffeners, Girders and Frames

1 Where the ends of girders are connected to structures such as bulkheads and tank tops, the end connections are to be balanced by effective supporting members on the opposite side of these structures.

2 The length of the frame-side arm of brackets connected to the frames or stiffeners of structures such as bulkheads or deep tanks is not to be less than one-eighth of l specified in the relevant Chapter, unless specified otherwise.

1.3.5 Brackets

1 The size of brackets is to be determined by **Table CS1.4** according to the length of longer arm.

2 The thickness of brackets is to be suitably increased where the depth of the brackets at the throat is less than two-thirds of the longer arm of the bracket.

3 Where lightening holes are cut into the brackets, the distance from the circumference of the hole to the free flange of the bracket is not to be less than the diameter of the lightening hole.

4 Where the length of the longer arm exceeds 800mm, the free edges of the brackets are to be stiffened by flanging or by other means, except where tripping brackets or the like are provided.

1.3.6 Modification of Span (l) for Thicker Brackets

Where brackets are not thinner than the girder plates, the value of l specified in **Chapter 8** and **Chapter 11** to **14** may be modified in accordance with the following:

(1) Where the sectional area of the face plate of the bracket is not less than one-half that of the girder and the face plate of the girder is carried to the bulkhead, deck, tank top, etc., l may be measured to a point 0.15 m inside the toe of the bracket.

(2) Where the sectional area of the face plate of the bracket is less than one-half that of the girder and the face plate of the girder is carried on to the bulkhead, deck, tank top, etc., l may be measured to a point where the sum of sectional areas of the bracket and its face plate outside the line of the girder is equal to the sectional area of the face plate of the girder, or to a point 0.15 m inside the toe of the bracket, whichever is the greater.

(3) Where brackets are provided and the face plates of girders extend along the free edge of brackets to the bulkhead, deck, tank top, etc., even if the free edge of brackets is curved, l is to be measured to the toe of the bracket.

(4) Brackets are not to be considered effective beyond the point where the arm along the girder is 1.5 *times* the length of the arm on the bulkhead, deck, tank top, etc.

(5) In no case is the modification of l at either end to exceed one-quarter of the overall length of the girder including the parts of end connection.

Table CS1.4 Brackets

(Unit: *mm*)

Length of longer arm	Thickness		Breadth of flange	Length of longer arm	Thickness		Breadth of flange
	Plane	Flanged			Plane	Flanged	
150	6.5	-	-	700	14.0	9.5	70
200	7.0	6.5	30	750	14.5	10.0	70
250	8.0	6.5	30	800	-	10.5	80
300	8.5	7.0	40	850	-	11.0	85
350	9.0	7.0	40	900	-	11.0	90
400	10.0	8.0	50	950	-	11.5	90
450	10.5	8.0	50	1,000	-	11.5	95
500	11.0	8.5	55	1,050	-	12.0	100
550	12.0	8.5	55	1,100	-	12.5	105
600	12.5	9.0	65	1,150	-	12.5	110
650	13.0	9.0	65	-	-	-	-

1.3.7 Equipment

Masts and riggings, cargo handling, mooring and anchoring arrangements and other fittings for which there are no particular requirements in this Part are to be of appropriate construction and arrangement suitable for their respective purposes; and tests are to be carried out to the satisfaction of the Surveyor, where deemed necessary.

1.3.8 Carriage of Oil or Other Flammable Liquid Substances

1 The requirements for construction and arrangement of ships for the carriage of fuel oils specified in this Part apply to ships carrying fuel oils having a flashpoint not less than 60°C determined by a closed cup test.

2 The construction and arrangement of ships for the carriage of fuel oils having a flashpoint less than 60°C determined by a closed cup test, are to be in accordance with the requirements provided in this Chapter, as well as other requirements deemed necessary by the Society.

3 The construction and arrangement of deep oil tanks of ships intended to carry cargo oils are to be in accordance with the requirements in **Chapter 24**.

4 In ships of not less than 400 *gross tonnage*, oils or other flammable liquid substances are not to be carried in compartments forward of the collision bulkhead.

1.3.9 Ship Identification Number

For cargo ships not less than 300 *gross tonnage* engaged on international voyages, the ship's identification number is to be permanently marked in accordance with **14.2, Part 1, Part C**.

1.4 Definitions

1.4.1 Application

The definitions of terms which appear in this Part are to be as specified in this Chapter, unless specified elsewhere. Terms not defined in other parts of the Rules are to be as specified in **Part A**.

1.4.2 Length of Ship

Length of ship (L) is the distance in *metres* on the designed maximum load line defined in **1.4.8(2)**, from the fore side of the stem to the aft side of the rudder post for ships with a rudder post, or to the axis of the rudder stock for ships without a rudder post. However, for ships with a cruiser stern, L is as defined above or 96% of the total length on the designed maximum load line, whichever is the greater.

1.4.3 Length for Freeboard

The length for freeboard (L_f) is 96% of the length in *metres* measured from the fore side of the stem to the aft side of the aft end shell plate on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length in *metres* measured from the fore side of the stem to the axis of the rudder stock on that waterline, whichever is the greater. However, where the stem contour is concave above the waterline at 85% of the least moulded depth, the forward terminal of this length is to be taken at the vertical projection to this waterline of the aftermost point of the stem contour. The waterline on which this length is measured is to be parallel to the load line defined in **1.4.9** in this Chapter.

1.4.4 Breadth of Ship

The breadth of ship (B) is the horizontal distance in *metres* from the outside of frame to the outside of frame measured at the broadest part of the hull.

1.4.5 Depth of Ship

The depth of ship (D) is the vertical distance in *metres* measured at the middle of L from the top of the keel to the top of the freeboard deck beam at side. Where watertight bulkheads extend to a deck above the freeboard deck and are recorded in the Register Book as effective up to that deck, the depth is to be measured to the bulkhead deck.

1.4.6 Midship Part of Ship

The midship part of ship is the part 0.4 L amidships unless otherwise specified.

1.4.7 End Parts of Ship

The end parts of ship are the parts within 0.1 L from each end of the ship.

1.4.8 Load Line and Designed Maximum Load Line

(1) Load line is the water line corresponding to each freeboard assigned in accordance with the provisions of **Part V**.

(2) Designed maximum load line is the water line corresponding to the full load condition.

1.4.9 Load Draught and Designed Maximum Load Draught

(1) Load draught is the vertical distance in *metres* measured at the middle of L_f from the top of the keel plate to the load line.

(2) Designed maximum load draught (d) is the vertical distance in *metres* from the top of the keel plate to the designed maximum load line measured at the middle of L.

1.4.10 Full Load Displacement

Full load displacement (W) is the moulded displacement in *tons* corresponding to the full load condition.

1.4.11 Block Coefficient

Block coefficient (C_b) is the coefficient given by dividing the volume corresponding to full load displacement (W) by LBd.

1.4.12 Strength Deck

The strength deck is the uppermost deck to which the shell plates extend at each section on the length of the ship. However, for superstructures (not including sunken superstructures) not exceeding 0.15 L in length, the strength deck is the deck just below the superstructure deck. For design reasons, this deck may be taken as the strength deck even for superstructures exceeding 0.15 L in length.

1.4.13 Freeboard Deck

1 The freeboard deck is normally the uppermost continuous deck. However, in cases where openings without permanent closing means exist on the exposed part of the uppermost continuous deck or where openings without permanent watertight closing means exist on the side of the ship below that deck, the freeboard deck is the continuous deck below that deck.

2 In a ship having a discontinuous freeboard deck, the lowest line of the exposed deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

3 Where a ship has multiple decks, an actual deck lower than one that complies with the freeboard deck defined above in **-1** or **-2** can be deemed the freeboard deck, and the load line can be marked corresponding to this deck in accordance with the requirements in **Part V**. However, this lower deck is to be continuous in a fore and aft direction at least between the machinery space and peak bulkheads and continuous athwartships. When this lower deck is stepped, the lowest line of the deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

Chapter 2 STEMS AND STERN FRAMES

2.1 Stems

2.1.1 Plate Stems

1 The thickness of steel plate stems is not to be less than that obtained from the following formula. Above and below the designed maximum load line, the thickness may be gradually tapered toward the stem head and the keel. At the upper end of the stem, it may be equal to the thickness of the side shell plating (at the fore end part) of the ship, and at the lower end of the stem, it may be equal to the thickness of the plate keel.

$0.10\,L + 4$ (mm)

2 Ribs are to be provided on the stem plates at an interval preferably not exceeding one *metre*, and where the radius of curvature at the fore end of the stem is large, proper reinforcement is to be made by providing it with a centre line stiffener or by any other means.

2.2 Stern Frames

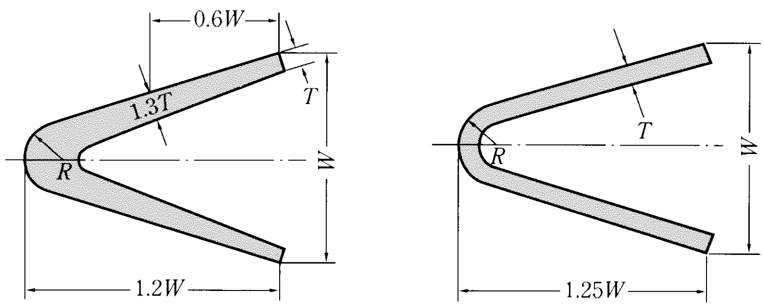
2.2.1 Application

The requirements in **2.2** apply only to stern frames without rudder post.

2.2.2 Propeller Posts

1 Propeller posts of cast steel stern frames and those of plate stern frames are to be of a shape suitable for the stream line at the after part of the hull, and the standard scantlings are given by the formulae and figures in **Fig. CS2.1**. Below the propeller boss, the breadth and thickness of the propeller post are to be gradually increased in order to provide sufficient strength and stiffness in proportion to the shoe pieces.

Fig. CS2.1 Standard Dimensions of Propeller Posts



Propeller Post of Cast Steel Stern Frame	Propeller Post of Steel Plate Stern Frame
W : $2.2L + 88$ (mm)	W : $2.5L + 100$ (mm)
T : $0.18L + 15$ (mm)	T : $2.2\sqrt{L} + 5.0$ (mm)
R : $0.40L + 16$ (mm)	R : $0.40L + 16$ (mm)

2 The thickness of the boss of the propeller post is not to be less than that obtained from the following formula:

$0.9\,L + 10$ (mm)

3 The propeller posts of cast steel stern frames and those of plate stern frames are to be provided with ribs at a suitable interval. Where the radius of curvature is large, a centre line stiffener is to be provided.

4 For ships with relatively high speed for their length, the scantlings of various parts of propeller posts are to be suitably increased.

2.2.3 Shoe Pieces

1 The scantling of each cross-section of the shoe piece (*See* **Fig. CS2.2**) is to be determined by the following formulae **(1)** to **(4)**, considering the bending moment and shear force acting on the shoe piece when the rudder force specified in 3.2 is applied to the rudder.

(1) The section modulus Z_Z around the vertical Z-axis is not to be less than:

$$Z_Z = \frac{MK_{sp}}{80} \ (cm^3)$$

Where:

M: Bending moment (N-m) at the section considered, which is obtained from the following formula

$$M = Bx \ (M_{max} = Bl)$$

Where:

B: Supporting force (N) in the pintle bearing as given in 3.4.1.

x: Distance (m) from the mid-point of the pintle bearing to the section considered, as specified in Fig. CS2.2

l: Distance (m) from the mid-point of the pintle bearing to the fixed point of the shoe piece, as specified in Fig. CS2.2

K_{sp}: Material factor for the shoe piece as given in 3.1.2

(2) The section modulus Z_Y around the transverse Y-axis is not to be less than:

$$Z_Y = 0.5Z_Z \ (cm^3)$$

Where:

Z_Z: As specified in **(1)**

(3) The total section area A_s of the members in the Y-direction is not to be less than:

$$A_s = \frac{BK_{sp}}{48} \ (mm^2)$$

Where:

B and K_{sp}: As specified in **(1)**

(4) At no section within length l is the equivalent stress to exceed $115/K_{sp}$ (N/mm^2).

The equivalent stress σ_e is to be obtained from the following formula:

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} \ (N/mm^2)$$

The bending stress and the shear stress acting on the shoe piece are to be obtained from the following formulae respectively:

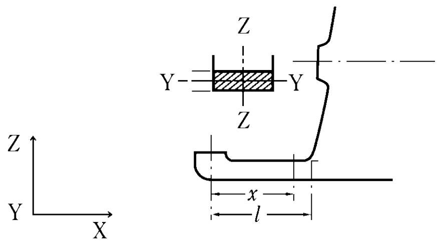
Bending stress: $\sigma_b = \frac{M}{Z_{z(x)}}$ (N/mm^2)

Shear stress: $\tau = \frac{B}{A_s}$ (N/mm^2)

Where:

$Z_Z, A_S, M,$ and B: As specified in **(1)** to **(3)**

Fig. CS2.2 Shoe piece



2 The thickness of the steel plates forming the main part of the shoe piece of steel plate stern frame is not to be less than that of the steel plates forming the main part of the propeller post. Ribs are to be arranged in the shoe piece below the propeller post, under brackets and at other suitable positions.

2.2.4 Heel Pieces

The heel piece of the stern frame is to be of a length at least three times the frame space at that part and is to be strongly connected to the keel.

2.2.5 Attachment of Stern Frame to Floor Plates

The stern frame is to be sufficiently extended upward at the part of the propeller post and connected securely to the transom floor of a thickness not less than the value obtained from the following formula. At the upper part of the extended stern frame, the transom floor is to be reinforced to avoid a sudden change in stiffness.

$0.035\,L + 10.0\ (mm)$

2.2.6 Gudgeons

1 The depth of gudgeons is not to be less than the length of the pintle bearing.

2 The thickness of the gudgeon is not to be less than $0.25\,d_{p0}$. For ships specified in **3.1.3**, the thickness of the gudgeon is to be appropriately increased.

Where:

d_{p0}: Actual diameter (mm) of the pintle measured at the outer surface of the sleeve

2.2.7 Rudder Trunk

1 The requirements of this paragraph apply to trunk configurations which are extended below stern frames and arranged in such a way that the trunk is stressed by forces due to rudder action.

2 Materials, welding and connection to hull

The steel used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0.23 % on ladle analysis or a carbon equivalent C_{EQ} not exceeding 0.41 %.

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration.

For rudder trunks extending below shells or skegs, the fillet shoulder radius r (mm) (*See* **Fig. CS2.3**) is to be as large as practicable and to comply with the following formulae:

$r = 0.1 d_l / K_T$

without being less than:

$r = 60$ when $\sigma \geq 40 / K_T$ (N/mm^2)

$r = 30$ when $\sigma < 40 / K_T$ (N/mm^2)

Where:

d_l: rudder stock diameter axis defined in **3.5.2**.

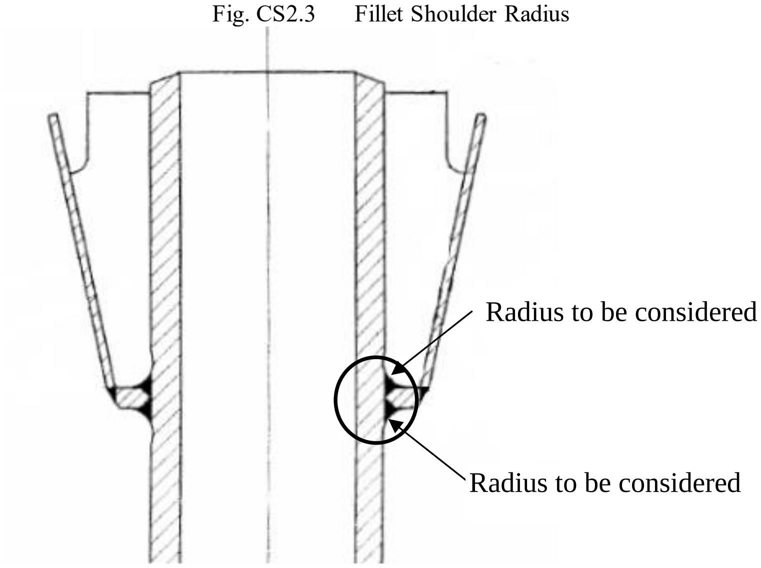
σ: bending stress in the rudder trunk (N/mm^2).

K_T: material factor for the rudder trunk as given in **3.1.2**.

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld. The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel are to be specially considered by the Society.

Fig. CS2.3 Fillet Shoulder Radius



3 Scantlings

The scantlings of the trunk are to be such that:

- the equivalent stress due to bending and shear does not exceed $0.35\,\sigma_Y$,
- the bending stress on welded rudder trunk is to be in compliance with the following formula:

  $\sigma \leq 80 / K_T$ (N/mm^2)

  with:

  σ: As defined in **-2**.

  K_T: Material factor for the rudder trunk as given in **3.1.2**, not to be taken less than 0.7

  σ_Y : Specified minimum yield stress (N/mm^2) of the material used

For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

Chapter 3 RUDDERS

3.1 General

3.1.1 Application*

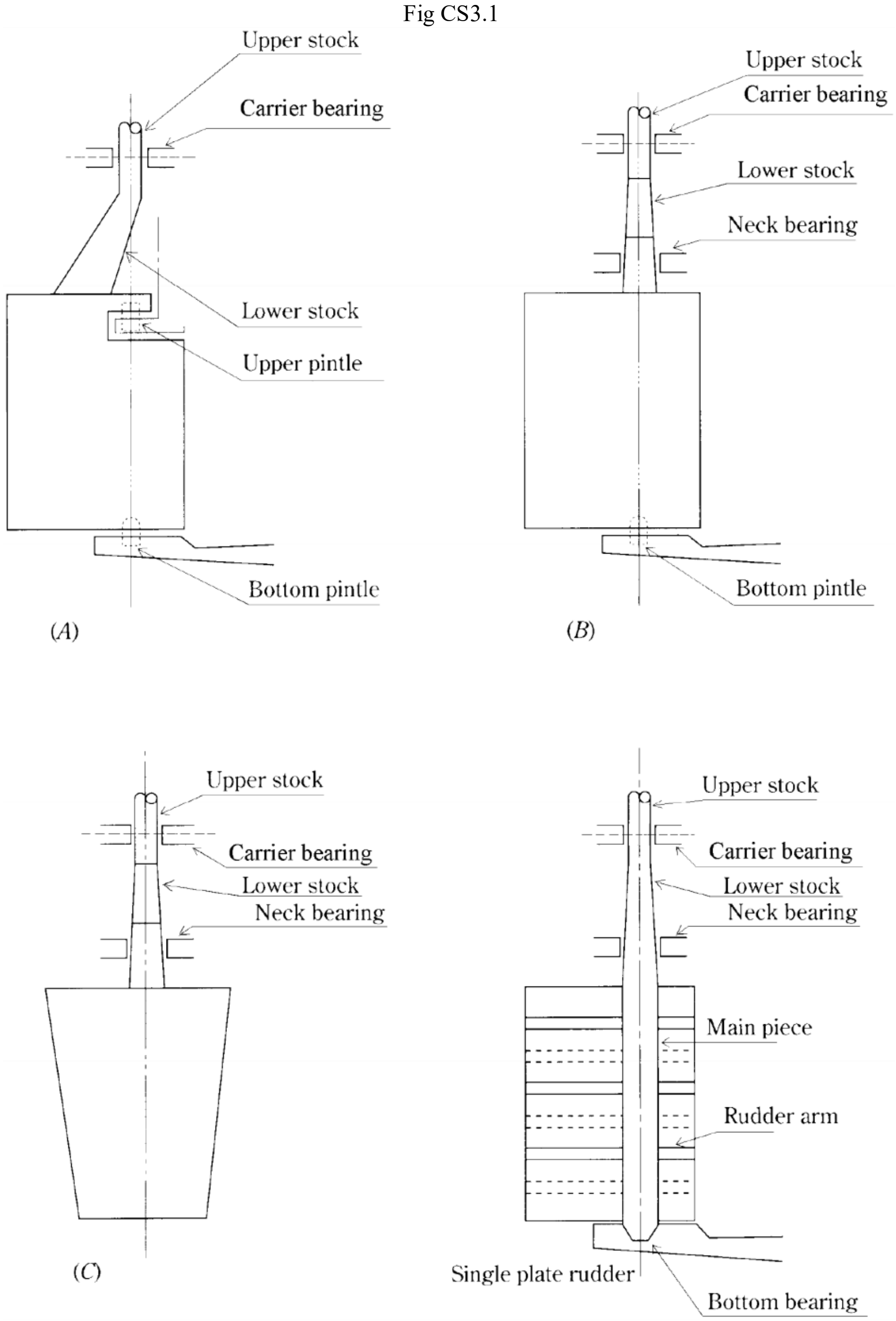
1 The requirements in this Chapter apply to double plate rudders of stream line section and ordinary shape, being divided into the following types, and single plate rudders.

(1) Type *A*: Rudders with upper and bottom pintles (*See* **Fig. CS3.1** (*A*))

(2) Type *B*: Rudders with neck bearing and bottom pintle (*See* **Fig. CS3.1** (*B*))

(3) Type *C*: Rudders having no bearing below the neck bearing (*See* **Fig. CS3.1** (*C*))

Fig CS3.1



2 This chapter applies to rudders made of steel for ships with $L_1 \geq 24\ m$

3 The construction of rudders having three or more pintles and of those having special shape or sectional form will be specially considered by the Society.

4 The construction of rudders designed to move more than 35 degrees on each side will be specially considered by the Society.

3.1.2 Materials

1 Welded members of rudders such as rudder plates, rudder frames, rudder main pieces are to be made of rolled steel conforming to the requirements in **Part K**.

2 The required scantlings may be reduced when high tensile steels are used. When reducing the scantling, the material factor K is to be the values specified in **1.3.1-2(1)**.

3 Rudder stocks, pintles, coupling bolts, keys, edge bars, and cast parts of rudders are to be made of rolled steel, steel forging or carbon steel casting conforming to the requirements in **Part K**.

4 For rudder stocks, pintles, coupling bolts, keys, and edge bars, the specified minimum yield stress is not to be less than 200 N/mm^2. The requirements in this Chapter are for materials with a specified minimum yield stress of 235 N/mm^2. If materials having a specified minimum yield stress differing from 235 N/mm^2 are used, the material factor K is to be determined by the following formula.

$$K = \left[\frac{235}{\sigma_Y}\right]^e$$

Where:

e: 0.75 for $\sigma_Y > 235\ N/mm^2$

e: 1.00 for $\sigma_Y \leq 235\ N/mm^2$

Where:

σ_Y: Specified minimum yield stress (N/mm^2) of material used, and is not to be taken as greater than 0.7 σ_B or 450 N/mm^2, whichever is the smaller

σ_B: Tensile strength (N/mm^2) of material used

5 When the rudder stock diameter is reduced because of using steels with a specified minimum yield stresses exceeding 235 N/mm^2, special consideration is to be given to deformation of the rudder stock to avoid excessive edge pressures at the edge of bearings.

3.1.3 Welding and Design Details

1 Slot welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of Type A rudder.

When slot welding is applied, the length of slots is to be minimum 75 mm with breadth of $2t$, where t is the rudder plate thickness (mm). The distance between ends of slots is not to be more than 125 mm (*See* **Fig. CS3.2**). The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

Continuous slot welds may be used in lieu of slot welds. When continuous slot welding is applied, the root gap is to be between 6-10 mm. The bevel angle is to be at least 15 degrees (*See* **Fig. CS3.2**).

2 In way of the rudder horn recess of Type A rudder the radii in the rudder plating (except in way of solid part in cast steel) are not to be less than 5 *times* the plate thickness, but in no case less than 100 mm. Welding in side plate are to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

3 Welds in the rudder side plating subjected to significant stresses from rudder bending and welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are to be made as full penetration welds. In way of highly stressed areas (e.g. cut-out of Type A rudders and upper part of Type C rudders), cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible, one side welding using steel backing bars is, in principle, to be performed. In such cases, one sided continuous welding is to be used to weld the steel backing bars to bevelled edge (*See* **Fig. CS3.3**). The bevel angle is to be at least 15 *degrees* for one sided welding. Other welding procedures, however, may be approved when deemed appropriate by the Society.

4 Requirements for welding and design details of rudder trunks are described in **2.2.7**.

5 Requirements for welding and design details when the rudder stock is connected to the rudder by horizontal flange coupling are described in **3.9.1-5**.

3.1.4 Equivalence

1 The Society may accept alternatives to requirements given in this Chapter, provided they are deemed to be equivalent.

2 Direct analyses adopted to justify an alternative design are to take into consideration all relevant modes of failure, on a case by case basis. These failure modes may include, amongst others: yielding, fatigue, buckling and fracture. Possible damages caused by cavitation are also to be considered.

3 If deemed necessary by the Society, lab tests, or full scale tests may be requested to validate the alternative design approach.

3.1.5 Increase in Diameter of Rudder Stock for Special Cases

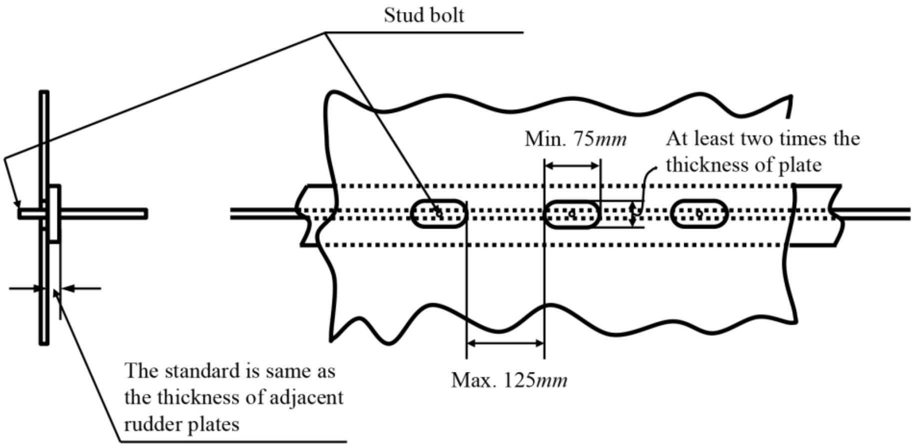
1 In ships which may be frequently steered at a large helm angle when sailing at their maximum speed, such as fishing vessels, the diameters of rudder stocks and pintles, as well as the section modulus of main pieces, are not to be less than 1.1 *times* those required in this Chapter.

2 In ships which might require quick steering, the diameter of rudder stocks is to be properly increased beyond the requirements in this Chapter.

3.1.6 Sleeves and Bushes

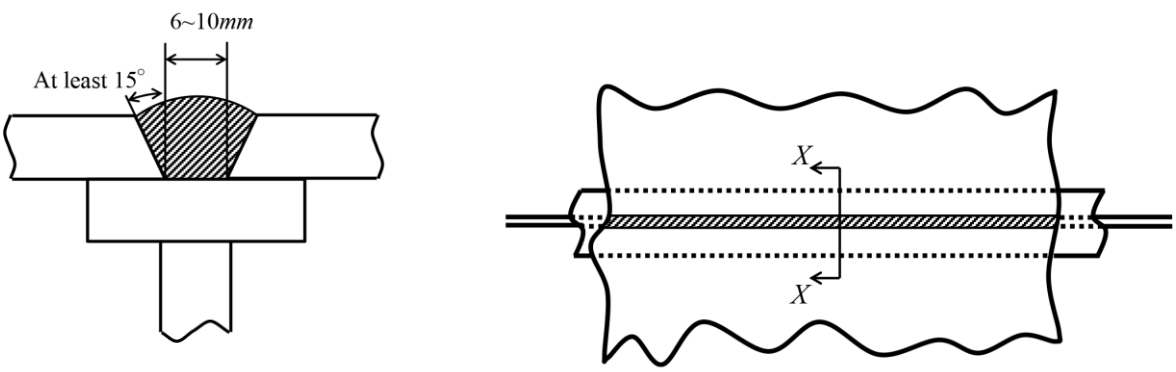
Bearings located up to well above the designed maximum load line are to be provided with sleeves and bushes.

Fig. CS3.2 Slot Welding and Continuous Slot Welding



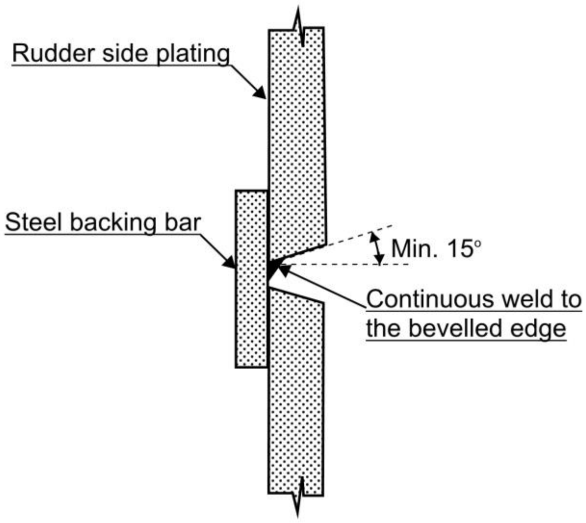
Note: The standard leg length of slot welding is F_1.

(a) Slot Welding



(b) Continuous Slot Welding

Fig. CS3.3 Use of Steel Backing Bar in Way of Full Penetration Welding of Rudder Side Plating



3.2 Rudder Force*

The rudder force F_R is used to determine the rudder scantlings and is obtained from the following formula, for ahead and astern conditions. However, when the rudder is arranged behind the propeller that produces an especially great thrust, the rudder force is to be appropriately increased.

$$F_R = K_1 K_2 K_3 132 A V^2 \ (N)$$

Where:

A: Area of rudder plate (m^2)

V: Speed of ship (kt)

When the speed is less than 10 *knots*, V is to be replaced by V_{min} determined from the following formula.

$$V_{min} = \frac{V+20}{3} \ (kt)$$

For the astern condition, the astern speed V_a as defined in **2.1.30, Part A** is to be obtained from the following formula. However, when the maximum astern speed is designed to exceed V_a, the design maximum astern speed is to be used.

$$V_a = 0.5V \ (kt)$$

Where:

K_1: Factor depending on the aspect ratio Λ of the rudder area obtained from the following formula.

$$K_1 = \frac{\Lambda+2}{3}$$

Λ: As obtained from the following formula

However, Λ is not required to be greater than 2.

$$\Lambda = \frac{h^2}{A_t}$$

h: Mean height of rudder (m), which is determined according to the coordinate system in **Fig. CS3.4**

A_t: Sum of rudder plate area A (m^2) and area of rudder post or rudder horn, if any, within the mean height of rudder h

K_2: Factor depending on the type of rudder profile (*See* **Table CS3.1**)

K_3: Factor depending on the location of rudder, as specified below:

For rudders outside the propeller jet: 0.8

For rudders behind a fixed propeller nozzle: 1.15

Otherwise: 1.0

Fig. CS3.4 Coordinate System of Rudders

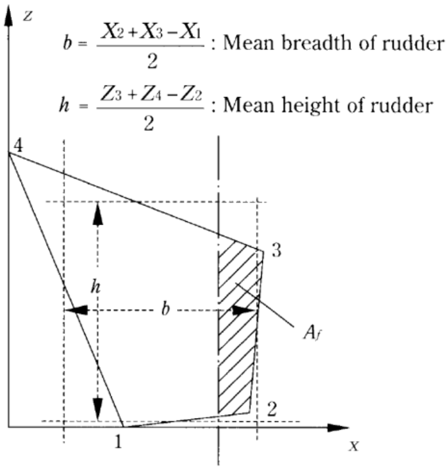
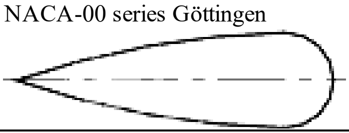
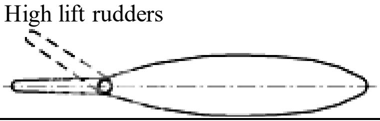
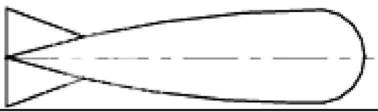
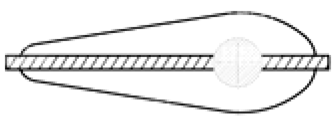


Table CS3.1 Factor K_2

Profile Type	K_2	
	Ahead condition	Astern condition
NACA-00 series Göttingen 	1.10	0.80
Flat side 	1.10	0.90
Hollow 	1.35	0.90
High lift rudders 	1.70	1.30
Fish tail 	1.40	0.80
Single plate 	1.00	1.00
Mixed profiles (e.g. HSVA)	1.21	0.90

3.3 Rudder Torque

3.3.1 Rudder Torque of Type *B* and *C* Rudders

The rudder torque T_R of Type *B* and *C* rudders is to be obtained for ahead and astern conditions, respectively, according to the following formula.

$$T_R = F_R r \quad (N\text{-}m)$$

Where:

F_R: As specified in **3.2**

r: Distance (m) from the centre of the rudder force on the rudder to the centreline of the rudder stock, determined by the following formula

$$r = b(\alpha - e)$$

For the ahead condition, r is not to be less than r_{min} obtained from the following formula.

$$r_{min} = 0.1b \quad (m)$$

Where:

b: Mean breadth (m) of rudder determined by the coordinate system in **Fig. CS3.4**

α: To be as follows:

For ahead condition: 0.33

For astern condition: 0.66

e: Balance factor of the rudder obtained from the following formula.

$$e = \frac{A_f}{A}$$

Where:

A_f: Portion of the rudder plate area (m^2) situated ahead of the centreline of the rudder stock

A: As specified in **3.2**

3.3.2 Rudder Torque of Type *A* Rudder

The rudder torque T_R of Type *A* rudders is to be obtained for the ahead and astern condition, respectively, according to the following formula:

$$T_R = T_{R1} + T_{R2} \quad (N\text{-}m)$$

For the ahead condition, T_R is not to be less than T_{Rmin} obtained from the following formula:

$$T_{Rmin} = 0.1F_R \frac{A_1 b_1 + A_2 b_2}{A} \quad (N\text{-}m)$$

Where:

T_{R1} and T_{R2}: Rudder torque (N-m) of portions A_1 and A_2, respectively

A_1 and A_2: Areas of respective rectangles (m^2) determined by dividing the rudder area into two parts so that $A = A_1 + A_2$ (A_1 and A_2 include A_{1f} and A_{2f} respectively), as specified in **Fig. CS3.5**. A_{1f} and A_{2f} are areas situated ahead of the centreline of the rudder stock.

b_1 and b_2: Mean breadth (m) of portions A_1 and A_2 respectively determined by applying **Fig. CS3.4**

F_R and A: As specified in **3.2**

T_{R1} and T_{R2}, the rudder torque of portions A_1 and A_2 respectively, are to be obtained from the following formulae.

$$T_{R1} = F_{R1} r_1 \quad (N\text{-}m)$$

$$T_{R2} = F_{R2} r_2 \quad (N\text{-}m)$$

F_{R1} and F_{R2}, the rudder force of portions A_1 and A_2, are to be obtained from the following formulae.

$$F_{R1} = F_R \frac{A_1}{A} \quad (N)$$

$$F_{R2} = F_R \frac{A_2}{A} \quad (N)$$

r_1 and r_2, the distances from each centre of rudder force of portions A_1 and A_2 to the centreline of the rudder stock, are to be determined from the following formulae.

$r_1 = b_1(\alpha - e_1)\ (m)$

$r_2 = b_2(\alpha - e_2)\ (m)$

e_1 and e_2, the balance factors of portions A_1 and A_2 respectively, are to be determined from the following formulae.

$e_1 = \frac{A_{1f}}{A_1}$, $e_2 = \frac{A_{2f}}{A_2}$

α is to be as follows:

For parts of a rudder not behind a fixed structure such as the rudder horn:

For ahead condition: 0.33

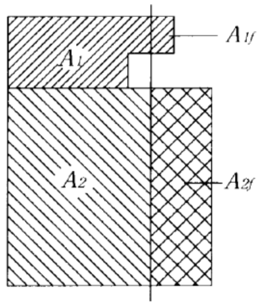
For astern condition: 0.66

For parts of a rudder behind a fixed structure such as the rudder horn:

For ahead condition: 0.25

For astern condition: 0.55

Fig. CS3.5 Division of Rudder



3.4 Rudder Strength Calculation

3.4.1 Rudder Strength Calculation

1 The rudder strength is to be sufficient to withstand the rudder force and rudder torque as given in **3.2** and **3.3**. When the scantling of each part of a rudder is determined, the following moments and forces are to be considered.

For rudder body: bending moment and shear force

For rudder stock: bending moment and torque

For pintle bearing and rudder stock bearing: supporting force

2 The bending moments, shear forces, and supporting forces to be considered are to be determined by direct calculation or by a simplified approximation method as deemed appropriate by the Society.

3.5 Rudder Stocks

3.5.1 Upper Stocks

The diameter d_u of the upper stock, which is the stock above the bearing centre of the rudder carrier required for the transmission of the rudder torque, is to be determined such that torsional stress does not exceed $68/K_S$ (N/mm^2).

Considering this, the diameter of the upper stock may be determined by the following formula:

$d_u = 4.2\sqrt[3]{T_R K_S}\ (mm)$

Where:

T_R: As specified in **3.3**

K_S: Material factor for rudder stock, as given in **3.1.2**

3.5.2 Lower Stocks

The diameter d_l of the lower stock, which is the stock below the bearing centre of the rudder carrier subject to the combined forces of torque and bending moment, is to be determined such that the equivalent stress in the rudder stock does not exceed $118/K_S$

(N/mm^2).

The equivalent stress σ_e is to be obtained from the following formula.

$$\sigma_e = \sqrt{{\sigma_b}^2 + 3{\tau_t}^2} \ (N/mm^2)$$

The bending stress and torsional stress acting on the lower stock are to be determined as follows:

Bending stress: $\sigma_b = \frac{10.2M}{{d_l}^3} \times 10^3 \ (N/mm^2)$

Torsional stress: $\tau_t = \frac{5.1T_R}{{d_l}^3} \times 10^3 \ (N/mm^2)$

Where:

M: Bending moment (N-m) at the section of rudder stock considered

T_R: As specified in **3.3**

When the horizontal section of the lower stock forms a circle, the lower stock diameter d_l may be determined by the following formula:

$$d_l = d_u \sqrt[6]{1 + \frac{4}{3}\left[\frac{M}{T_R}\right]^2} \ (mm)$$

Where:

d_u: Diameter of upper stock (mm) as given in **3.5.1**

For a spade rudder with trunk extending inside the rudder, the rudder stock scantlings are to be checked against the following two cases:

(1) pressure applied on the entire rudder area; and

(2) pressure applied only on rudder area below the middle of neck bearing.

3.6 Rudder Plates, Rudder Frames and Rudder Main Pieces of Double Plate Rudders

3.6.1 Rudder Plate

The rudder plate thickness t is not to be less than that obtained from the following formula:

$$t = 5.5S\beta \sqrt{\left(d_s + \frac{F_R \times 10^{-4}}{A}\right) K_{p1}} + 2.5 \ (mm)$$

Where:

d_s: Scantling draught (m) (*See* **15.2.1-1**)

A and F_R: As specified in **3.2**

K_{pl}: Material factor for rudder plate as given in **3.1.2**

β: To be obtained from the following formula:

$$\beta = \sqrt{1.1 - 0.5\left(\frac{S}{a}\right)^2} \ maximum \ 1.0 \ (\frac{a}{S} \geq 2.5)$$

Where:

S: Spacing (m) of horizontal or vertical rudder frames, whichever is smaller

a: Spacing (m) of horizontal or vertical rudder frames, whichever is greater

The rudder plating in way of the solid part is to be of increased thickness per **3.7.4**.

3.6.2 Rudder Frames

1 The rudder body is to be stiffened by horizontal and vertical rudder frames enabling it to withstand bending like a girder.

2 The standard spacing of horizontal rudder frames is to be obtained from the following formula:

$$0.2\left(\frac{L}{100}\right) + 0.4 \ (m)$$

3 The standard distance from the vertical rudder frame forming the rudder main piece to the adjacent vertical frame is to be 1.5 *times* the spacing of horizontal rudder frames.

4 The thickness of rudder frames is not to be less than 8 *mm* or 70% of the thickness of the rudder plates as given in **3.6.1**, whichever is greater.

3.6.3 Rudder Main Pieces

1 Vertical rudder frames forming the rudder main piece are to be arranged forward and afterward of the centreline of the rudder stock at a distance approximately equal to the thickness of the rudder if the main piece consists of two rudder frames, or at the centreline of the rudder stock if the main piece consists of one rudder frame.

2 The section modulus of the main piece is to be calculated in conjunction with the vertical rudder frames specified in **-1** above and the rudder plates attached thereto. The breadth of the rudder plates normally taken for the calculation is to be as follows:

(1) Where the main piece consists of two rudder frames, the breadth is 0.2 *times* the length of the main piece.

(2) Where the main piece consists of one rudder frame, the breadth 0.16 *times* the length of the main piece.

3 The section modulus and the web area of a horizontal section of the main piece are to be determined so that bending stress, shear stress and equivalent stress should not exceed the following stresses, respectively.

(1) In general, except in way of rudder recess sections where **(2)** applies

Bending stress: $\sigma_b = \dfrac{110}{K_m}$ (N/mm^2)

Shear stress: $\tau = \dfrac{50}{K_m}$ (N/mm^2)

Equivalent stress: $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = \dfrac{120}{K_m}$ (N/mm^2)

Where:

K_m: Material factor for the rudder main piece as given in **3.1.2**

(2) In way of the recess for the rudder horn pintle on Type *A* rudder

Bending stress: $\sigma_b = 75$ (N/mm^2)

Shear stress: $\tau = 50$ (N/mm^2)

Equivalent stress: $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = 100$ (N/mm^2)

Note: The stresses in **(2)** apply equally to high tensile and ordinary steels.

4 The upper part of the main piece is to be so constructed as to avoid structural discontinuity.

5 The maintenance openings are to be rounded off properly.

3.6.4 Connections

Rudder plates are to be effectively connected to rudder frames, free from defects, with due attention paid to the workmanship.

3.6.5 Painting and Draining

The internal surfaces of rudders are to be coated with effective paint, and a means for draining is to be provided at the bottom of the rudders.

3.7 Connections of Rudder Blade Structure with Solid Parts

3.7.1 Solid Part Protrusions

Solid parts in forged or cast steel, which house the rudder stock or the pintle, are to be provided with protrusions, except where not required as indicated below.

These protrusions are not required when the web plate thickness is less than:

- 10 *mm* for web plates welded to the solid part on which the lower pintle of Type *A* rudders is housed and for vertical web plates welded to the solid part of the rudder stock coupling of Type *C* rudders.
- 20 *mm* for other web plates.

3.7.2 General

The solid parts are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

3.7.3 Minimum Section Modulus of the Connection with the Rudder Stock Housing

The section modulus of the cross-section of the structure of the rudder blade (cm^3) formed by vertical web plates and rudder plating, which is connected with the solid part where the rudder stock is housed is to be not less than:

$$c_S d_l^3 \left(\frac{H_E - H_X}{H_E}\right)^2 \frac{K_{pl}}{K_S} 10^{-4} (cm^3)$$

Where:

c_S :Coefficient, to be taken equal to:

$c_S = 1.0$ if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate

$c_S = 1.5$ if there is an opening in the considered cross-section of the rudder

d_l :Rudder stock diameter (mm)

H_E : Vertical distance between the lower edge of the rudder blade and the upper edge of the solid part (mm)

H_X : Vertical distance between the considered cross-section and the upper edge of the solid part (mm)

K_{pl} : Material factor for the rudder blade plating as given in **3.1.2**.

K_s : Material factor for the rudder stock as given in **3.1.2**.

The actual section modulus of the cross-section of the structure of the rudder blade is to be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating (m) to be considered for the calculation of section modulus is to be not greater than:

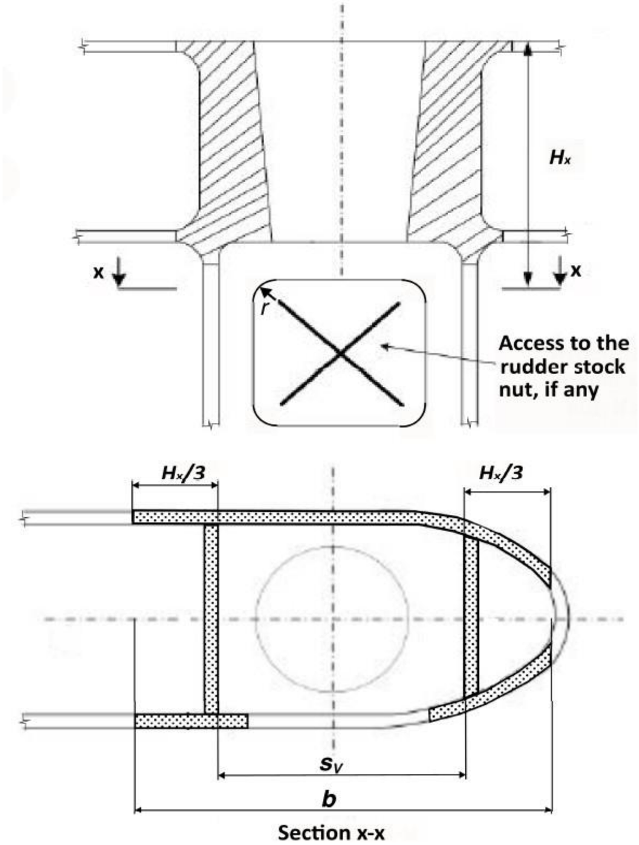
$$b = s_V + 2\frac{H_X}{3}$$

Where:

s_V: spacing between the two vertical webs (m) (*See* **Fig. CS3.6**)

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they are to be deducted (*See* **Fig. CS3.6**).

Fig. CS3.6 Cross-section of the Connection between Rudder Blade Structure and Rudder Stock Housing (in cases where there is an opening on only one side)



3.7.4 Thickness of the Horizontal Web Plates

The thickness of the horizontal web plates connected to the solid parts (mm), as well as that of the rudder blade plating between these webs, is to be not less than the greater of the following values:

$t_H = 1.2\,t$

$$t_H = 0.045\frac{d_S^2}{s_H}$$

Where:

t : As defined in **3.6.1**

d_S : Diameter (mm) to be taken equal to:

d_l for the solid part housing the rudder stock

d_p for the solid part housing the pintle

d_l : Rudder stock diameter (mm) defined in **3.5.2**

d_p : Pintle diameter (mm) defined in **3.10.1**

s_H : Spacing between the two horizontal web plates (mm).

The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

3.7.5 Thickness of the Vertical Web Plates

The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained (mm) from **Table CS3.2**.

The increased thickness is to extend below the solid piece at least to the next horizontal web.

Table CS3.2 Thickness of Side Plating and Vertical Web Plates

Type of rudder	Thickness of vertical web plates (mm)		Thickness of rudder plating (mm)	
	Rudder blade without opening	Rudder blade with opening	Rudder blade without opening	Area with opening
Type A, B and single plate rudders	1.2 t	1.6 t	1.2 t	1.4 t
Type C rudders	1.4 t	2.0 t	1.3 t	1.6 t
t = thickness of the rudder plating, in mm, as defined in **3.6.1**				

3.8 Rudder Plates, Rudder Arms and Rudder Main Pieces of Single Plate Rudders

3.8.1 Rudder Plates

The rudder plate thickness t is not to be less than that obtained from the following formula:

$$t = 1.5SV\sqrt{K_{p1}} + 2.5 \quad (mm)$$

Where:

S: Spacing (m) of rudder arms, not to exceed 1 (m)

V: Ship speed (kt) as specified in **3.2**

K_{pl}: Material factor for rudder plate as given in **3.1.2**

3.8.2 Rudder Arms

1 The thickness of rudder arms is not to be less than that of rudder plates.

2 The section modulus of rudder arms is not to be less than the value obtained from the following formula. This section modulus, however, may be reduced gradually toward the edge of the rudder plate.

$$0.5SC_1^2V^2K_a \quad (cm^3)$$

Where:

C_1: Horizontal distance (m) from the aft edge of the rudder plate to the centre of the rudder stock

K_a: Material factor for the rudder arm as given in **3.1.2**

S and *V*: As specified in **3.8.1**

3.8.3 Rudder Main Pieces

The diameters of main pieces are not to be less than those of lower rudder stocks. In rudders having no bearing below the neck bearing, the main piece diameter may be reduced gradually within the lower 1/3 area of the rudder, and may be 75% of the specified diameter at the bottom part.

3.9 Couplings between Rudder Stocks and Main Pieces

3.9.1 Horizontal Flange Couplings*

1 Coupling bolts are to be reamer bolts, and at least 6 reamer bolts are to be provided in each coupling.

2 The diameter of coupling bolts d_b is not to be less than the dimension obtained from the following formula:

$$d_b = 0.62\sqrt{\frac{d^3K_b}{ne_mK_S}}\ (mm)$$

Where:

d: Stock diameter (mm), the greater of the diameters d_u or d_l according to **3.5.1** and **3.5.2**

n: Total number of bolts

e_m: Mean distance (mm) of the bolt axes from the centre of the bolt system

K_s: Material factor for the rudder stock as given in **3.1.2**

K_b: Material factor for the bolts as given in **3.1.2**

3 The thickness of the coupling flanges t_f is not to be less than that determined by the following formula, provided that the thickness is not less than $0.9d_b$ (mm).

$$t_f = d_b\sqrt{\frac{K_f}{K_b}}\ (mm)$$

Where:

K_f: Material factor for flange as given in **3.1.2**

K_b: As specified in **-2**

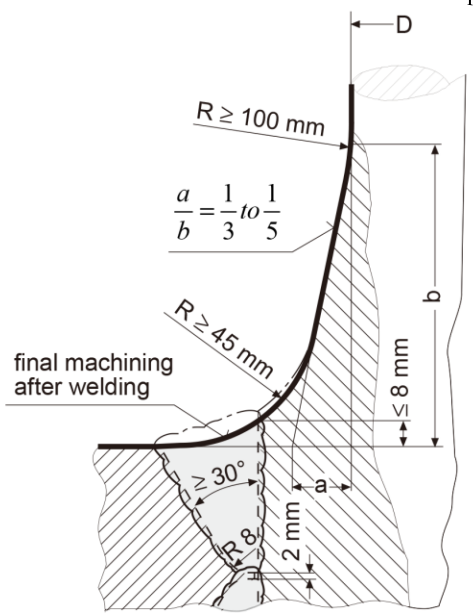
d_b: Bolt diameter (mm), determined by a number of bolts not exceeding 8

4 The width of material between the perimeter of the bolt holes of the coupling flanges and the perimeter of the flange is not to be less than $0.67d_b$ (mm).

5 The welded joint between the rudder stock and the flange is to be made in accordance with **Fig.CS3.7** or equivalent.

6 Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

Fig. CS3.7 Welded Joint between Rudder Stock and Coupling Flange



3.9.2 Vertical Flange Couplings

1 Coupling bolts are to be reamer bolts, and at least 8 reamer bolts are to be used in each coupling.

2 The diameter of the coupling bolts d_b is not to be less than the dimension obtained from the following formula.

$$d_b = \frac{0.81d}{\sqrt{n}}\sqrt{\frac{K_b}{K_S}}\ (mm)$$

Where:

d: Stock diameter (mm), the greater of the diameters d_u or d_l according to **3.5.1** and **3.5.2**

n: Number of bolts

K_b: Material factor for bolts as given in **3.1.2**

K_s: Material factor for the rudder stock as given in **3.1.2**

3 The first moment of area M of the bolts about the centreline of the coupling flange is not to be less than the value obtained from the following formula:

$M = 0.00043d^3$ (cm^3)

4 The thickness of the coupling flanges is not to be less than the bolt diameter.

5 The width of the flange material between the perimeter of the bolt holes and the perimeter of the flange is not to be less than $0.67d_b$ (mm).

6 Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

3.9.3 Cone Couplings with Key

1 Tapering and coupling length

Cone couplings that are mounted or dismounted without hydraulic arrangements (e.g. oil injection and hydraulic nut) are to have a taper c on diameter of 1:8 ~ 1:12. (*See* **Fig. CS3.8** and **Fig.CS3.10**)

Where:

$$c = (d_0 - d_e)/\ell_c$$

The diameters d_0 and d_u are shown in **Fig. CS3.8** and the cone length ℓ_c is defined in **Fig. CS3.10**.

The cone coupling is to be secured by a slugging nut. The nut is to be secured, e.g. by a securing plate.

The cone shapes are to fit exactly. The coupling length ℓ is to be, in general, not less than $1.5d_0$.

2 For couplings between stock and rudder a key is to be provided, the shear area of which is not to be less than:

$$a_s = \frac{17.55M_Y}{d_k\sigma_{Y1}}\quad (cm2)$$

Where:

M_Y : Design yield moment of rudder stock (N-m)

$$M_Y = 0.02664\frac{{d_u}^3}{K_S}$$

Where the actual diameter d_{ua} is greater than the calculated diameter d_u, the diameter d_{ua} is to be used. However, d_{ua} applied to the above formula need not be taken greater than 1.145 d_u.

d_u : Stock diameter (mm) according to **3.5.1**

K_S : Material factor for stock as given in **3.1.2**

d_k : Mean diameter of the conical part of the rudder stock (mm) at the key

σ_{Y1}: Specified minimum yield stress of the key material (N/mm^2)

The effective surface area (cm^2) of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5M_Y}{d_k\sigma_{Y2}}\quad (cm2)$$

Where:

σ_{Y2}: Specified minimum yield stress of the key, stock or coupling material (N/mm^2) whichever is less.

3 The dimensions of the slugging nut as specified in **-1** are to be as follows (*See* **Fig. CS3.8**):

External thread diameter: $d_g \geq 0.65d_0$ (mm)

Height: $h_n \geq 0.6d_g$ (mm)

Outside diameter: $d_n \geq 1.2d_e$ or $1.5d_g$ (mm), whichever is greater

4 It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to **3.9.4-2** and **-3** for a torsional moment $M_Y' = 0.5\ M_Y$.

5 Notwithstanding the provisions in **-1** above, where a key is fitted to couplings between stocks and rudders, and it is considered that rudder torque is transmitted by friction at the couplings, the scantlings of the key as well as push-up force and push-up length are to be at the discretion of the Society .

6 The nuts fixing the rudder stocks are to be provided with efficient locking devices.

7 Couplings of rudder stocks are to be properly protected from corrosion.

Fig. CS3.8 Cone Coupling with Key

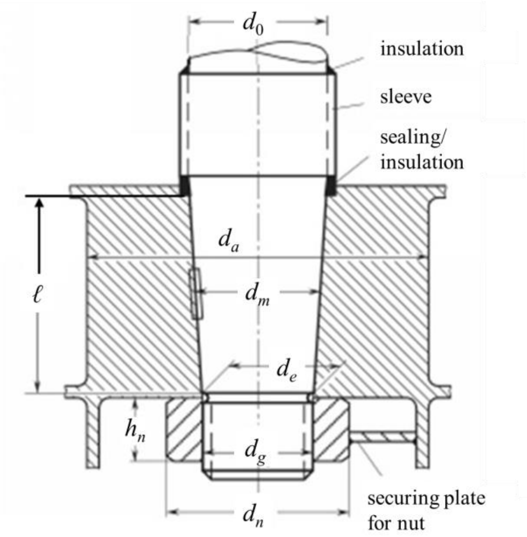


Fig. CS3.9 Gudgeon Outer Diameter

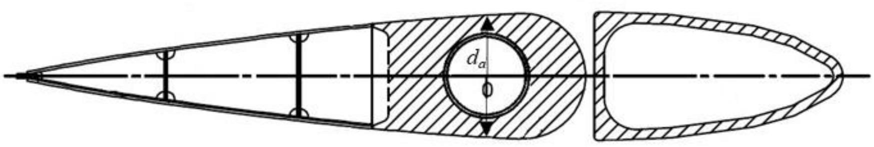
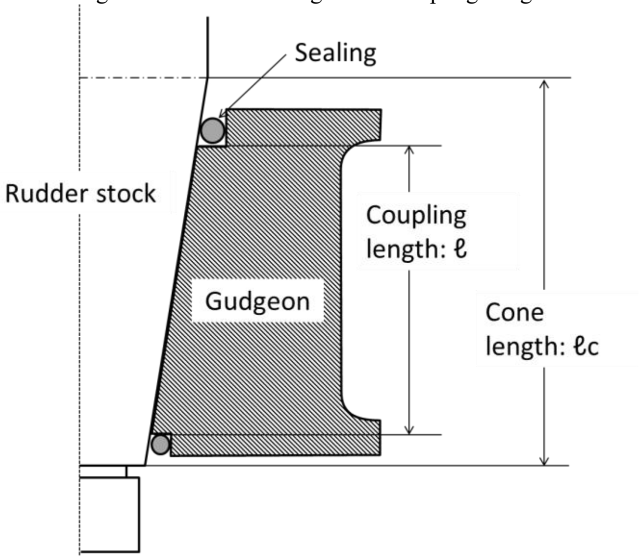


Fig. CS3.10 Cone Length and Coupling Length



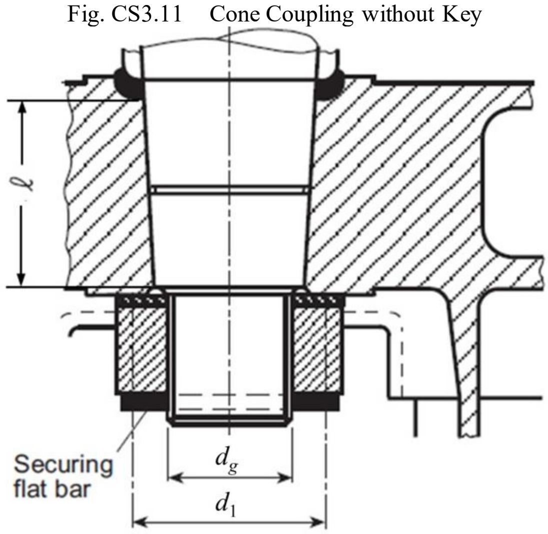
3.9.4 Cone Couplings with Special Arrangements for Mounting and Dismounting the Couplings

1 Where the stock diameter exceeds 200 *mm*, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone is to be more slender, c ≈1:12 to ≈1:20.

In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle.

For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to **-2** and **-3** respectively.

Fig. CS3.11 Cone Coupling without Key



2 Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2M_Y}{d_m^2 \ell \pi \mu_0} 10^3 \qquad (N/mm2)$$

$$p_{req2} = \frac{6M_c}{\ell^2 d_m} 10^3 \qquad (\mathrm{N/mm2})$$

Where:

M_Y : Design yield moment of rudder stock, as defined in **3.9.3-2** (*N-m*)

d_m : Mean cone diameter (*mm*) (*See* **Fig. CS3.8**)

ℓ : Coupling length (*mm*)

μ_0 : Frictional coefficient, equal to 0.15

M_c : Bending moment in rudder stock at the top of the cone coupling (e.g. in case of spade rudders) (N-m)

For spade rudder with trunk extending inside the rudder, the coupling is to be checked against the following two cases:

(1) pressure applied on the entire rudder area; and

(2) pressure applied only on rudder area below the middle of neck bearing.

It has to be proved by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure is to be determined by the following formula:

$$p_{perm} = \frac{0.95\sigma_Y(1-\alpha^2)}{\sqrt{3+\alpha^4}} - p_b$$

$$p_b = \frac{3.5M_c}{d_m \ell^2}10^3$$

Where:

σ_Y : Specified minimum yield stress (N/mm^2) of the material of the gudgeon

$$\alpha = \frac{d_m}{d_a}$$

d_m : Mean cone diameter (mm) (*See* **Fig. CS3.8**)

d_a : Outer diameter of the gudgeon (*See* **Fig. CS3.8** and **Fig. CS3.9**. The least diameter is to be considered.) (mm)

The outer diameter of the gudgeon is not to be less than 1.25 d_0, with d_0 defined in **Fig. CS3.8**.

3 Push-up length

The push-up length $\Delta\ell$ (mm) is to comply with the following formula:

$$\Delta\ell_1 \le \Delta\ell \le \Delta\ell_2$$

Where:

$$\Delta\ell_1 = \frac{p_{req}d_m}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8R_{tm}}{c}$$

$$\Delta\ell_2 = \frac{p_{perm}d_m}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8R_{tm}}{c}$$

R_{tm} : Mean roughness (mm) taken equal to about 0.01 mm

c : Taper on diameter according to **3.9.3-1**

E : Young's modulus (N/mm^2), to be taken as 2.06×10^5

Note: In case of hydraulic pressure connections the required push-up force P_e for the cone (N) may be determined by the following formula:

$$P_e = p_{req}\, d_m \pi \ell \left(\frac{c}{2} + 0.02\right)$$

The value 0.02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed.

Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by the Society.

3.10 Pintles

3.10.1 Diameter of Pintles

The diameter of pintles d_p is not to be less than the dimension obtained from the following formula.

$$d_p = 0.35\sqrt{BK_p} \ (mm)$$

Where:

B: Reaction force in bearing (N)

K_p: Material factor for pintles as given in **3.1.2**

3.10.2 Construction of Pintles

1 Tapering

Pintles are to be constructed as taper bolts with a taper on the diameter not exceeding the following values, and capable of being fitted to the cast parts of the rudders. The nuts fixing the pintles are to be provided with efficient locking devices.

(1) For pintles to be assembled and locked with slugging nuts: 1:8 ~ 1:12

(2) For pintles mounted with hydraulic arrangements (e.g. oil injection and hydraulic nut): 1:12 ~ 1:20

2 Push-up pressure for pintle

The required push-up pressure for pintle in case of dry fitting (N/mm^2) is to be determined by p_{req1} as given below. The required push-up pressure for pintle in case of oil injection fitting (N/mm^2) is to be determined by the maximum pressure of p_{req1} and p_{req2} as given below.

$$p_{req1} = 0.4\frac{B d_0}{d_m^2 \ell}$$

$$p_{req2} = \frac{6M_{bp}}{\ell^2 d_m} \times 10^3 \ (N/mm^2)$$

Where:

B : As defined in **3.10.1**

d_m, ℓ : As defined in **3.9.4-2**

d_0 : Pintle diameter (mm) (*See* **Fig. CS3.8**)

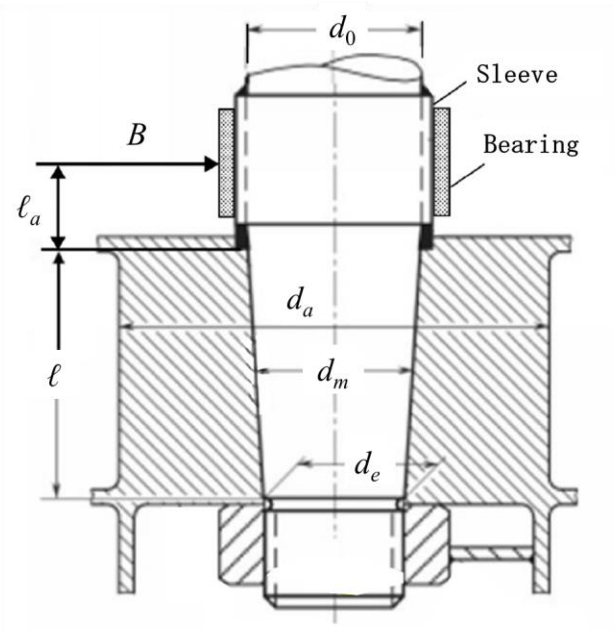
M_{bp}: bending moment in the pintle cone coupling (N-m) to be determined by:

$M_{bp} = B\ell_a$

ℓ_a: Length between middle of pintle-bearing and top of contact surface between cone coupling and pintle (m) (*See* **Fig. CS3.12**)

The required push up length $\Delta\ell_1$ is to be calculated similarly as in **3.9.4-3**, using the required push-up pressure (as defined above) and properties for the pintle.

Fig. CS3.12 Pintle Cone Coupling Indicating ℓ_a



3 The minimum dimensions of the threads and the nuts of pintles are to be determined by applying the requirements in **3.9.3-3** correspondingly.

4 The taper length of the pintle is not to be less than the maximum actual diameter of the pintle.

5 Pintles are to be properly protected from corrosion.

3.11 Bearings of Rudder Stocks and Pintles

3.11.1 Sleeves and Bushes

1 Rudder stock bearing

Sleeves and bushes are to be fitted in way of bearings. For rudder stocks and pintles having diameter less than 200 mm, sleeves in way of bushes may be provided optionally. The minimum thickness of sleeves and bushes is to be equal to:

- $t_{min} = 8\ mm$ for metallic materials and synthetic material
- $t_{min} = 22\ mm$ for lignum material

2 Pintle bearing

The thickness of any sleeve or bush is neither to be less than:

$$t = 0.01\sqrt{B} \quad (mm)$$

Where:

B : As specified in **3.10.1**

nor than the minimum thickness defined in **-1**.

3.11.2 Minimum Bearing Surface

The bearing surface A_b (defined as the projected area: *length* × *outside diameter of sleeve*) is not to be less than the value obtained from the following formula.

$$A_b = \frac{B}{q_a} \quad (mm^2)$$

Where:

B: As specified in **3.10.1**

q_a: Allowable surface pressure (N/mm^2)

The allowable surface pressure for the various bearing combinations is to be taken from **Table CS3.3**. When verified by tests, however, values different from those in this Table may be taken.

3.11.3 Bearings Dimensions

The length/diameter ratio of the bearing surface is not to be greater than 1.2.

The bearing length L_p of the pintle is to be such that

$$d_{p0} \leq L_p \leq 1.2 d_{p0}$$

Where:

d_{p0}: As specified in **2.2.6**

3.11.4 Bearing Clearances

With metal bearings, clearances are not to be less than $d_{bs}/1000+1.0$ (mm) on the diameter. d_{bs} is the internal diameter of the bush.

If non-metallic bearing material is used, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties. This clearance is not to be taken as less than 1.5 mm on the bearing diameter unless a smaller clearance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

Table CS3.3 Allowable Surface Pressure q_a

Bearing material	q_a (N/mm^2)
Lignum vitae	2.5
White metal(oil-lubricated)	4.5
Synthetic material with hardness greater than 60 Shore D 1)	5.5 2)
Steel 3), bronze and hot-pressed bronze-graphite materials	7.0

Notes:

1: Indentation hardness test at the temperature of 23°C and the humidity of 50%, is to be carried out according to a recognized standard. Synthetic bearings are to be of the type as deemed appropriate by the Society.

2: Surface pressures exceeding 5.5 N/mm^2 may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm^2.

3: Stainless and wear-resistant steel in an approved combination with a stock liner.

3.12 Rudder Accessories

3.12.1 Rudder Carriers

Suitable rudder carriers are to be provided according to the form and the weight of the rudder, and care is to be taken to provide efficient lubrication at the support.

3.12.2 Prevention of Jumping

A suitable arrangement is to be provided to prevent the rudder from jumping due to wave shocks.

Chapter 4 SUBDIVISIONS

4.1 General

4.1.1 Application

The requirements in this Chapter apply to cargo ships engaged in international voyages, of not less than 500 gross tonnage with a length for freeboard (L_f) which is not less than 80 m. However, tankers specified in **Chapter 24** of this Part, ships to which the requirements in **Part N** or **Part S** apply, and those ships specifically approved by the Society may be exempted.

4.1.2 Definitions

For the purpose of this chapter, the following definitions apply.

(1) "Compartment" is a part of the hull formed by shells, decks and bulkheads which are to be watertight as a rule.

(2) "Group of compartments" is a part of the hull formed by two or more compartments which are adjacent with each other.

(3) "Deepest subdivision draught" (d_s) is the summer draught assigned to the ship in accordance with the requirements of **Part V**.

(4) "Light service draught" (d_l) is the service draught corresponding to the lightest anticipated loading and associated tankage, including, however, such ballast as may be necessary for stability and/or immersion. Passenger ships should include the full complement of passengers and crew on board.

(5) "Partial subdivision draught" (d_p) is the draught which corresponds to the summation of light service draught specified in **(4)** above and 60% of the difference between the light service draught and the deepest subdivision draught.

(6) "Subdivision length of the ship" (L_s) is the greatest projected moulded length in metres of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

(7) "Amidships" is at the middle of the length for freeboard (L_f).

(8) "Aft terminal" is the aft limit of L_s.

(9) "Forward terminal" is the forward limit of L_s.

(10) "Trim" is the difference between the draught forward and the draught aft, where the draughts are measured at the perpendiculars for the forward and aft ends of the length for freeboard (L_f), disregarding any rake of keel.

(11) "Breadth of ship" (B') is the greatest moulded breadth in metres of the ship at or below the deepest subdivision draught.

(12) "Draught" (d') is the vertical distance in metres from keel line to the water line in question at the amidships.

(13) "Permeability of a space" (μ) is the proportion of the immersed volume of that space (a compartment or group of compartments) which can be occupied by water. The value μ is shown in **Table CS4.1-1** and **Table CS4.1-2** according to the purpose of the space. However, in spaces intended for the carriage of liquid, the more stringent value of μ is to be taken when calculating the subdivision index in **4.2**. Where substantiated by calculations and specifically accepted by the Society, other figures for permeability specified in **Table CS4.1-1** and **Table CS4.1-2** may be used notwithstanding the provision above.

(14) "Internal opening" is the opening provided in decks or bulkheads forming a compartment excluding those that are completely exposed.

(15) "External opening" is the opening provided in shells, exposed decks or bulkheads forming a compartment.

(16) "Timber" means all types of wooden material covered by the *Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011* (*IMO* resolution *A*.1048(27)), including both round and sawn wood but excluding wood pulp and similar cargo.

(17) "Timber deck cargo" means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck.

(18) "Machinery spaces" are spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion.

Table CS4.1-1 Permeability of General Compartment

Space	Locker	Accommodation	Machinery	Void	Liquid
Permeability	0.60	0.95	0.85	0.95	0 or 0.95

Table CS4.1-2 Permeability of Cargo Compartment

Space for	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Dry cargo spaces	0.70	0.80	0.95
Container spaces	0.70	0.80	0.95
Ro-ro spaces	0.90	0.90	0.95
Cargo liquids	0.70	0.80	0.95

4.2 Subdivision Index

4.2.1 Subdivision Index

1 The value of the Required Subdivision Index (R) is to be given by the following formula:

$$R = 1 - \left[1/\left(1 + \frac{L_s}{100} \cdot \frac{R_0}{1 - R_0}\right)\right]$$

R_0 : The value calculated in accordance with the following formula.

$$R_0 = 1 - \frac{128}{L_s + 152}$$

2 The Attained Subdivision Index (A) for ship is to be not less than the Required Subdivision Index (R), calculated in accordance with **-1** above. A is obtained by the summation of the partial indices A_s, A_p and A_l, weighted as shown and calculated for the draughts d_s, d_p and d_l specified in **4.1.2(3)** to **(5)** in accordance with the following formula:

$$A = 0.4A_s + 0.4A_p + 0.2A_l$$

Each partial index is a summation of contributions from all damage cases taken in consideration, using the following formula:

$$A_x = \Sigma p_i \cdot s_i$$

Where, each partial index is not less than $0.5R$.

A_x: Each partial index corresponding to draughts, d_s, d_p and d_l specified in **4.1.2(3)** to **(5)**.

p_i: Probability that a compartment or a group of compartments in question may be flooded (hereinafter referred to as "compartment flooding probability"), which is to be in accordance with the requirements in **4.2.2**.

s_i: Probability of survival after flooding a compartment or a group of compartments in question (hereinafter referred to as "survival probability"), which is to be in accordance with the requirements in **4.2.3**.

i: Indication of each compartment or group of compartments in question.

3 Partial index (A_x) is to be calculated under the following conditions:

(1) As a minimum, the calculation of A is to be carried out at level trim for the deepest subdivision draught and the partial subdivision draught. The estimated service trim may be used for the light service draught. Where any anticipated service condition within the draught range from d_s to d_l, the trim variation in comparison with the calculated trim is greater than 0.005 L_f, one or more additional calculations of A are to be performed for the same draughts but including sufficient trims to ensure that, for all intended service conditions, the difference in trim in comparison with the reference trim used for one calculation will be not more than $0.005L_f$. Each additional calculation of A is to comply with **-2** above.

(2) All flooding in compartments and groups of compartments over the entire ship's subdivision length is to be taken into account.

(3) Assumed extent of hull damage is the following:

(a) Vertical extent is to be up to $d' + 12.5(m)$ from the baseline. However, if a lesser extent will give a more severe result, then such an extent is to be assumed.

(b) Horizontal extent of damage is measured inboard from Ship's side, at a right angle to the centreline at the level of the deepest subdivision draught and damage of the transverse extent greater than half breadth ($B'/2$) of the ship may be exempted. Where the ship has a compartment formed by longitudinal watertight bulkheads which are not on the ship's centreline, all damage which extend from the outmost compartment (hereinafter referred to as "wing compartment") to the ship's centreline are to be assumed.

(4) In the flooding calculations carried, only one breach of the hull damage need to be assumed and only one free surface need to

be considered.

(5) In the case of unsymmetrical arrangements, the calculated A value is to the mean value obtained from calculations involving both sides. Alternatively, it is to be taken as that corresponding to the side which evidently gives the least favourable result.

(6) When determining the positive righting lever (GZ) of the residual stability curve in the intermediate and final equilibrium stages of flooding, the displacement for the intact loading condition is to be used. All calculations are to be done with the ship freely trimming.

4.2.2 Compartment Flooding Probability (p_i)

1 The Compartment Flooding Probability (p_i) for a compartment or group of compartments is to be determined by the following **(1)**, **(2)** or **(3)** according to the number of damaged compartment.

(1) Where the damage involves a single zone only:

$$p_i = p(x1_j, x2_j) \cdot [r(x1_j, x2_j, b_k) - r(x1_j, x2_j, b_{k-1})]$$

Where:

$x1$: The distance (m) from the aft terminal of L_s to the aft end of the zone in question

$x2$: The distance (m) from the aft terminal of L_s to the forward end of the zone in question

b: The mean transverse distance (m) measured at right angles to the centreline at the deepest subdivision draught between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane is to be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell. If the upper part of a longitudinal bulkhead is below the deepest subdivision draught the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision waterline. In any case, b is not to be taken greater than $B'/2$.

j: The aftmost damage zone number involved in the damage starting with no.1 at the stern

k: The number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centre line. However, value of k according to side shell is to be taken as zero.

$p(x1, x2)$: It is specified in **-2**.

$r(x1, x2, b)$: It is specified in **-3**. However, $r(x1, x2, b_0)$ is to be taken as zero.

(2) Where the damage involves two adjacent zones:

$$\begin{aligned} p_i = {} & p(x1_j, x2_{j+1}) \cdot [r(x1_j, x2_{j+1}, b_k) - r(x1_j, x2_{j+1}, b_{k-1})] \\ & - p(x1_j, x2_j) \cdot [r(x1_j, x2_j, b_k) - r(x1_j, x2_j, b_{k-1})] \\ & - p(x1_{j+1}, x2_{j+1}) \cdot [r(x1_{j+1}, x2_{j+1}, b_k) - r(x1_{j+1}, x2_{j+1}, b_{k-1})] \end{aligned}$$

(3) Where the damage involves three or more adjacent zones:

$$\begin{aligned} p_i = {} & p(x1_j, x2_{j+n-1}) \cdot [r(x1_j, x2_{j+n-1}, b_k) - r(x1_j, x2_{j+n-1}, b_{k-1})] \\ & - p(x1_j, x2_{j+n-2}) \cdot [r(x1_j, x2_{j+n-2}, b_k) - r(x1_j, x2_{j+n-2}, b_{k-1})] \\ & - p(x1_{j+1}, x2_{j+n-1}) \cdot [r(x1_{j+1}, x2_{j+n-1}, b_k) - r(x1_{j+1}, x2_{j+n-1}, b_{k-1})] \\ & + p(x1_{j+1}, x2_{j+n-2}) \cdot [r(x1_{j+1}, x2_{j+n-2}, b_k) - r(x1_{j+1}, x2_{j+n-2}, b_{k-1})] \end{aligned}$$

n: The number of adjacent damage zones involved in the damage

2 The Compartment Flooding Probability (p_i) is to be determined by the following **(1)**, **(2)** or **(3)** according to longitudinal position of compartment under consideration.

(1) Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

In case $J \leq J_k$:

$$p(x1, x2) = p_1 = \frac{1}{6} J^2 (b_{11} J + 3 b_{12})$$

In case $J > J_k$:

$$\begin{aligned} p(x1, x2) = p_2 = {} & -\frac{1}{3} b_{11} J_k^3 + \frac{1}{2}(b_{11} J - b_{12}) J_k^2 + b_{12} J J_k - \frac{1}{3} b_{21} (J_n^3 - J_k^3) \\ & + \frac{1}{2}(b_{21} J - b_{22})(J_n^2 - J_k^2) + b_{22} J (J_n - J_k) \end{aligned}$$

J: Non-dimensional damage length given below:

$$J = \frac{(x2 - x1)}{L_s}$$

x1 and *x2* are specified in **-1** above.

J_k: As given by the following formula:

$$J_k = \frac{J_m}{2} + \frac{1 - \sqrt{1 - \frac{55}{6}J_m + \frac{121}{4}{J_m}^2}}{11}$$

$$J_m = \min\left\{\frac{10}{33}, \frac{60}{L_s}\right\}$$

b_{11}, b_{12}, b_{21} and b_{22}: Coefficient given by the following:

$$b_{11} = \frac{1}{6}\left(\frac{2}{(J_m - J_k)J_k} - \frac{11}{{J_k}^2}\right)$$

$$b_{12} = 11$$

$$b_{21} = -\frac{1}{6}\frac{1}{(J_m - J_k)^2}$$

$$b_{22} = \frac{1}{6}\frac{J_m}{(J_m - J_k)^2}$$

J_n: Normalized length of a compartment or group of compartments is to be taken as the lesser of J and J_m:

(2) Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

In case $J \leq J_k$:

$$p(x1, x2) = \frac{1}{2}(p_1 + J)$$

In case $J > J_k$:

$$p(x1, x2) = \frac{1}{2}(p_2 + J)$$

x1, *x2*, p_1, p_2, J and J_k are specified in **(1)** above.

(3) Where the compartment or groups of compartments considered extends over the entire subdivision length (L_s):

$p(x1, x2) = 1$

x1 and *x2* are specified in **(1)** above.

3 The factor $r(x1, x2, b)$ is to be determined by the following formulae:

$$r(x1, x2, b) = 1 - (1 - C) \cdot \left[1 - \frac{G}{p(x1, x2)}\right]$$

x1, *x2* and *b* are specified in **-1** above.

C: Coefficient given by the following:

$$C = 12J_b(-45J_b + 4)$$

J_b: Coefficient given by the following:

$$J_b = \frac{b}{15B'}$$

G: As given by the following formula:

Where the compartment or groups of compartments considered extends over the entire subdivision length (L_s):

$$G = G_1 = \frac{1}{2}b_{11}{J_b}^2 + b_{12}J_b$$

Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$$G = G_2 = -\frac{1}{3}b_{11}{J_0}^3 + \frac{1}{2}(b_{11}J - b_{12}){J_0}^2 + b_{12}JJ_0$$

Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$$G = \frac{1}{2} \cdot (G_2 + G_1 \cdot J)$$

b_{11}, b_{12} and J are specified in -2 above.

J_0: Coefficient given by the following:

$$J_0 = \min(J, J_b)$$

4.2.3 Probability of Survival (s_i)

1 The Probability of Survival (s_i) for any damage case at any initial loading condition is to be obtained from the formula:

$$s_i = \min\{s_{\text{intermediate,i}} \text{ or } s_{\text{final,i}}\}$$

$s_{\text{intermediate,i}}$: Probability to survive all intermediate flooding stages until the final equilibrium stage. It is calculated in accordance with -2.

$s_{\text{final,i}}$: Probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with -3.

2 The factor $s_{\text{intermediate,i}}$ is to be obtained from the following formula.

(1) For cargo ships fitted with cross-flooding devices, the factor $s_{\text{intermediate,i}}$ is taken as the least of the value obtained from all flooding stages including the stage before equalization, if any, and is to be calculated as follows. Where the intermediate heel angle exceeds 30º, $s_{\text{intermediate,i}}$ is to be taken as 0.

$$s_{\text{intermediate,i}} = \left[\frac{GZ_{\max}}{0.05} \cdot \frac{Range}{7}\right]^{\frac{1}{4}}$$

$GZ_{\max}$: Maximum positive righting lever (m) up to the angle θ_v . However, in the calculations of $s_{\text{intermediate,i}}$, it is not to be taken as more than 0.05 m.

θ_v : Angle (°), at any stage of flooding, where the righting lever becomes negative, or the angle (°) at which an opening incapable of being closed weathertight becomes submerged.

$Range$: Range of positive righting levers (°) measured from the angle θ_e . However, the positive range is to be taken up to the angle θ_v and, in the calculations of $s_{\text{intermediate,i}}$, it is not to be taken as more than 7°.

θ_e : Equilibrium heel angle (°) at any stage of flooding.

(2) Where cross-flooding fittings are required, the time for equalization is not to exceed 10 min.

(3) For cargo ships not fitted with cross-flooding devices the factor $s_{\text{intermediate,i}}$ is taken as 1, except if the Administration considers that the stability in intermediate stages of flooding may be insufficient, it is to require further investigation thereof.

3 The factor $s_{\text{final,i}}$ is to be obtained from the following formula.

$$s_{\text{final,i}} = K \cdot \left[\frac{GZ_{\max}}{0.12} \cdot \frac{Range}{16}\right]^{\frac{1}{4}}$$

K: Coefficient given by the following:

$K = 1.0$ if $\theta_e \leq \theta_{\min}$

$K = 0$ if $\theta_e \geq \theta_{\max}$

$$K = \sqrt{\frac{\theta_{\max} - \theta_e}{\theta_{\max} - \theta_{\min}}} \quad \text{Otherwise}$$

where, $\theta_{\min}$ is 25° and $\theta_{\max}$ is 30° for cargo ships.

θ_v : Angle (°), at any stage of flooding, where the righting lever becomes negative, or the angle (°) at which an opening incapable of being closed weathertight becomes submerged.

$GZ_{\max}$: As specified in -2 above. However, in the calculations of $s_{\text{final,i}}$, it is not to be taken as more than 0.12 (m).

θ_e : Equilibrium heel angle (°) at any stage of flooding.

$Range$: As specified in -2 above. However, the positive range is to be taken up to the angle θ_v and, in calculations of $s_{\text{final,i}}$, it is not to be taken as more than 16°.

4 Where horizontal watertight boundaries are fitted above the waterline under consideration, the factor (s) calculated for the lower compartment or group of compartments is to be obtained by multiplying the value as determined in -1 above by the factor v_m given by following formula.

$v_m = v(H_{j,n,m}, d') - v(H_{j,n,m-1}, d')$

$H_{j,n,m}$: It is the least height (m) above the baseline within the longitudinal range of $x1_{(j)} \dots x2_{(j+n-1)}$ of the m-th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

$H_{j,n,m-1}$: It is the least height (m) above the baseline within the longitudinal range of $x1_{(j)} \dots x2_{(j+n-1)}$ of the m-1-th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

j, n, $x1$ and $x2$ are specified in **4.2.2-1**.

m: It is each horizontal boundary counted upwards from the waterline under consideration;

$v(H_{j,n,m}, d')$ and $v(H_{j,n,m-1}, d')$: Coefficient given by the following:

$$v(H, d') = 0.8\frac{(H-d')}{7.8} \qquad \text{if } H_m - d' \leq 7.8\ m$$

$$v(H, d') = 0.8 + 0.2\left[\frac{(H-d')-7.8}{4.7}\right] \qquad \text{Otherwise}$$

$v(H_{j,n,m}, d')$ is to be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $x1_{(j)} \dots x2_{(j+n-1)}$, and $v(H_{j,n,0}, d')$ is to be taken as 0.

v_m is to be taken as 0, if v_m determined by above formula is taken as less than 0, and v_m is to be taken as 1, if v_m determined by above formula is taken as more than 1.

5 Where the requirement in **-4** above is applied, in general, each contribution dA to the Attained Subdivision Index A is obtained from the formula:

$$dA = p_i \cdot [v_1 \cdot s_{\min 1} + (v_2 - v_1) \cdot s_{\min 2} + \dots + (1 - v_{m-1}) \cdot s_{\min m}]$$

v_m: The value calculated in accordance with **-4** above;

$s_{\min}$: The least factor of s for all combinations of damages obtained when the assumed damage extends from the assumed damage height H_m downwards.

6 Probability of survival (s_i) is to be taken as 0 in cases where the final waterline (in consideration of sinkage, heel and trim) immerses the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of the probability of survival (s_i). Such openings are to include air pipes, ventilators and openings which to be closed by means of weathertight doors or hatch covers.

7 The probability of survival (s_i) is to be taken as 0 if, taking into account sinkage, heel and trim, any of the following **(1)** to **(3)** occur in any intermediate stage or in the final stage of flooding:

(1) Immersion of any vertical escape hatch in the freeboard deck

(2) Any controls intended for the operation of watertight doors, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the freeboard deck become inaccessible or inoperable

(3) Immersion of piping or ventilation ducts located within the assumed extent of damage and carried through a watertight boundary if this can lead to the progressive flooding of compartments not assumed as flooded.

8 Notwithstanding the requirements given in **-7** above, where compartments are assumed to be flooded due to progressive flooding in the damage stability calculations, s_i may be taken as $s_{\text{intermediate},i}$ for the flooding of those compartments under consideration.

9 Unsymmetrical flooding is to be in accordance with following **(1)** and **(2)**.

(1) Unsymmetrical flooding is to be kept to a minimum consistent with the efficient arrangements.

(2) Where it is necessary to correct large angles of heel, the means adopted is to, where practicable, be self-acting, but in any case where controls to equalization devices are provided they are to be operable from above the freeboard deck. These fittings together with their controls are to be acceptable to the Society.

10 Where the ship carries timber deck cargo, the calculation of the probability of survival (s_i) may be modified as deemed appropriate by the Society.

4.3 Openings

4.3.1 Internal Openings

1 Internal openings below the final damage waterline or the intermediate waterline and considered to prevent progressive flooding in the calculation of the subdivision index are to be watertight.

2 The number of internal openings required to be watertight under the requirement of **-1** above is to be minimized, and their closing appliances are to comply with the following **(1)** to **(5)**. Relaxation of the requirements regarding water openings above the freeboard deck may be considered, where deemed by the Society that the safety of the ship is not impaired.

(1) Closing appliances are to be of ample strength and watertightness for water pressure to the equilibrium/intermediate waterplane.

(2) Closing appliances for internal openings which are used while at sea are to be sliding watertight doors complying with the following conditions.

(a) Capable of being remotely closed from the bridge

(b) Capable of being opened and closed by hand locally, from both sides of with the ship listed 30 degrees to either side

(c) Provided with position indicators on the bridge and at all operating positions showing whether the doors are open or closed

(d) Provided with an audible alarm which will sound at the door position whenever such a door is remotely closed

(e) Power, control and indicators for which are to be operable in the event of main power failure

Particular attention is to be paid to minimizing the effect of control system failure.

(3) Closing appliances normally closed at sea, are to be watertight closing appliances complying with the following conditions.

(a) Capable of being opened and closed by hand locally, from both sides of the opening with the ship listed 30 degrees to either side

If hinged, it is to be of a quick acting or single action type.

(b) Provided with position indicators showing whether the doors are open or closed on the bridge and at all operating positions Such indicators are to be operable in the event of main power failure.

(c) Provided with notices affixed to both sides of the closing devices stating “To be kept closed at sea” unless provided with a means of remote closure

(d) Be in accordance with **(2)(d)** and **(e)** above, if operable remotely

(4) Watertight doors or ramps fitted to internally subdivided cargo spaces are to be permanently closed at sea, and are to comply with the following conditions.

(a) Not to be remotely controlled

(b) Provided with notices affixed to both sides of the doors stating “Not to be opened at sea”

(c) Fitted with a device which prevents unauthorized opening where accessible during the voyage

(5) Other closing appliances which are kept permanently closed at sea are to comply with **(4)(a)** and **(b)** above.

3 Bolted watertight manholes kept permanently closed at sea, need not apply to the provisions of **-2** above.

4 Closing appliances for the internal openings required to be watertight under the requirement of **-1** above are to comply with the provisions of **13.3**, unless otherwise provided in **-2** above.

4.3.2 External Openings

1 All external openings below the final damage waterline in the calculation of the subdivision index are to be watertight.

2 The closing appliances for external openings required to be watertight under **-1** above are to comply with the following **(1)** to **(4)**.

(1) Closing appliances are to be of ample strength and watertightness for water pressure to the equilibrium/intermediate waterplane.

(2) Indicators showing whether the doors are open or closed are to be provided on the bridge and all operating positions. Such indicators are to be operable in the event of main power failure. However, such indicators are not required for cargo hatch covers, fixed side scuttles and bolted manholes.

(3) Closing appliances are to be provided with a notice shown as **(a)** or **(b)** affixed at their operating positions. However, such notices are not required for cargo hatch covers, fixed side scuttles and bolted manholes.

(a) Closing appliances which are normally closed at sea are to have notices stating, “To be kept closed at sea”.

(b) Closing appliances which are to be permanently closed at sea are to have notices stating, “Not to be opened at sea”.

(4) Closing appliances for openings in the shell plating below the bulkhead deck are to be permanently closed at sea. Such closing

appliances are to be fitted with a device which prevents unauthorized opening if they are accessible during voyage, except where specially approved by the Society.

3 Closing appliances for external openings above the equilibrium/intermediate waterplane but below the bulkhead deck are to be permanently closed at sea, and are to comply with the following **(1)** to **(3)**.

(1) Indicators showing whether the doors are open or closed are to be provided on the bridge and at all operating positions. Such indicators are to be operable in the event of main power failure. However, such indicators are not required for fixed side scuttles.

(2) Closing appliances are to be provided with a notice affixed at their operating positions stating "Not to be opened at sea". However, such notices are not required for fixed side scuttles.

(3) Closing appliances for openings in the shell plating accessible during the voyage are to be fitted with a device which prevents unauthorized opening, except where specially approved by the Society.

Chapter 5 SINGLE BOTTOMS

5.1 General

5.1.1 Application

1 The requirements in this Chapter apply to the single bottoms of ships whose double bottom is omitted partially or wholly in accordance with the requirements in **6.1.1-2** or **-3**.

2 The bottom constructions in way of fore and after peaks are to be in accordance with the requirements in **9.2** and **9.3**.

5.2 Centre Girder

5.2.1 Arrangement and Construction

All single bottom ships are to have centre girder composed of web plates and face plates, and the centre girder is to extend as far forward and afterward as practicable.

5.2.2 Web Plates

1 The thickness of web plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$0.065L + 5.2 \ \ (mm)$$

2 The height of web plates is not to be less than that of floors.

5.2.3 Face Plates

1 The thickness of face plates specified in **5.2.1** is not to be less than the thickness of web plates amidships and the face plates are to extend from the collision bulkhead to the after peak bulkhead.

2 The sectional area of face plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$0.6L + 9 \ \ (cm^2)$$

3 The breadth of face plates is not to be less than that obtained from the following formula:

$$2.3L + 160 \ \ (mm)$$

5.3 Side Girders

5.3.1 Arrangement

Side girders are to be so arranged that their spacing is not more than 2.5m between the centre girder and the side shell plating.

5.3.2 Construction

The side girders are to be composed of continuous web plates in association with face plates, and they are to extend as far forward and afterward as practicable.

5.3.3 Web Plates

1 The thickness of web plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$5.8 + 0.042L \ \ (mm)$$

2 The thickness of web plates in the engine space is not to be less than that required in **5.2.2**.

5.3.4 Face Plates

The thickness of face plates is not to be less than that required for the web plates, and the sectional area of face plates amidships is not to be less than that obtained from the following formula. Beyond the midship part, the sectional area may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$0.45L + 8.8 \ \ (cm^2)$$

5.4 Floor Plates

5.4.1 Arrangement

1 In ships with the bottom of transverse framing, the standard spacing of floors is as stipulated in 7.2.1.

2 In ships with the bottom of longitudinal framing, floors are to be so arranged that their spacing is not more than about 3.5 *m*.

5.4.2 Shapes

1 Upper edges of floor plates at any part are not to be below the level of the upper edges at the centre line.

2 In the midship part, the depth of floors measured at a distance d_0 specified in 5.4.3-1, from the inner edge of the frames along the upper edge of floors is not to be less than 0.5 d_0. (*See* Fig. CS5.1) Where frame brackets are provided, the depth of floors at the inner edge of brackets may be 0.5 d_0.

3 In ships having an unusually large rise of floor, the depth of floor plates at the centre line is to be suitably increased.

4 Face plates provided on the floor plates are to be continuous from the upper part of the bilge at one side to the upper part of the bilge on the opposite side in case of curved floors, or extend over the floor plate in case of floors connected by frame brackets.

5.4.3 Scantlings

1 The scantlings of floor plates are not to be less than that obtained from the following formulae:

Depth at the centre line: 0.0625 l (*m*)

Thickness: 10 d_0 + 4.0 (*mm*) or 12 *mm*, whichever is the smaller

Section modulus: 4.27 Shl^2 (cm^3)

Where:

S: Spacing (*m*) of floors

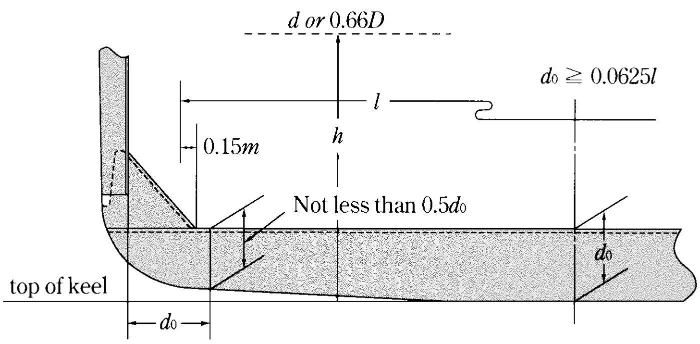
h: d (*m*) or 0.66 D (*m*), whichever is the greater

l: Distance (*m*) between the toes of frame brackets plus 0.3 *m* measured at amidship

Where curved floors are provided, the length l may be suitably modified. (*See* Fig. CS5.1)

d_0: Depth (*m*) of floor plates at the centre line

Fig. CS5.1 Shape of Floors



2 The thickness of face plates on the floor plates is not to be less than that required for the floor plates, and the breadth of face plates is to be adequate for lateral stability of the floors.

3 Beyond 0.5 L amidships, the thickness of floor plates may be gradually reduced to 0.85 *times* the value specified in -1 at the end parts of the ship, except for the flat bottom forward.

4 Floors under engines and thrust seats are to be of ample depth and to be especially strengthened. Their thickness is not to be less than that of the centre girder web plates.

5 At the strengthened bottom forward specified in 6.9.2, the depth of floor plates is to be increased, or alternatively, the section modulus of floor plates required in -1 is to be suitably increased.

5.4.4 Frame Brackets

The size of frame brackets is to be in accordance with the following requirements, and the free edge of brackets is to be stiffened.

(1) The brackets are to extend above the top of the keel to a height twice the required depth of floors at the centre line.

(2) The arm length of brackets measured from the outer edge of frames to the bracket toe along the upper edge of floors is not to be less than the required depth of floors at the centre line.

(3) The thickness of brackets is not to be less than that of the floors required in 5.4.3.

5.4.5 Limber Holes

Limber holes are to be provided above the frames in all floor plates on each side of the centre line, and in addition, at the lower turn of the bilge in ships having flat bottoms.

5.4.6 Lightening Holes

Lightening holes may be provided in floor plates. Where the holes are provided, appropriate strength compensation is to be made by increasing the floor depth or by some other suitable means.

5.4.7 Floor Plates Forming Part of Bulkheads

Floor plates forming part of bulkheads are to be in accordance with the requirements in **Chapters 13** and **14**.

5.5 Longitudinals

5.5.1 Spacing

The standard spacing of bottom longitudinals is obtained from the following formula:

$2L + 550$ (mm)

5.5.2 Longitudinals

The section modulus of bottom longitudinals is not to be less than that obtained from the following formula:

$9Shl^2$ (cm^3)

Where:

l: Spacing (m) of solid floors

S: Spacing (m) of bottom longitudinals

h: Vertical distance (m) from the longitudinals to a point of $d + 0.026\ L$ above the top of the keel

5.6 Construction of the Bottom Forward

Construction of the bottom forward is to be in accordance with the requirements in 6.9.

Chapter 6 DOUBLE BOTTOMS

6.1 General

6.1.1 Application

1 Ships are to be provided with watertight double bottoms extending from the collision bulkhead to the after peak bulkhead. The longitudinal system of framing is, in general, to be adopted. The inner bottom is to be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge, and is not lower at any part than a plane parallel with the keel line and which is located not less than a vertical distance h (m) measured from the keel line specified in **2.1.48, Part A of the Rules**.

$h = B'/20$

B' : It is specified in **4.1.2(11)**.

However, in no case is the value of h to be less than 0.76 m, and need not be taken as more than 2.0 m.

2 Part or all of double bottoms may be omitted for ships deemed by the Society to not require a double bottom for special reasons and for ships deemed appropriate by the Society which are less than 500 *gross tonnage* or which are not engaged in international voyages.

3 For ships other than ships specified in **-2** above, double bottoms may be omitted in way of watertight tanks on the condition that the safety of the ship is not impaired in the event of bottom or side damage.

4 The requirements in this Chapter may be suitably modified, where partial double bottoms are provided and where special arrangements such as longitudinal bulkheads or inner skins are made to reduce the unsupported breadth of double bottoms.

5 Where the longitudinal system of framing is transformed into the transverse system, or depth of the double bottom changes suddenly, special care is to be taken for the continuity of strength by means of additional intercostal girders or floors.

6 Special consideration is to be given to the double bottom structure of the hold when it is intended to carry heavy cargoes or where cargo loads can not be treated as evenly distributed loads.

6.1.2 Manholes and Lightening Holes

1 Manholes and lightening holes are to be provided in all non-watertight members to ensure accessibility and ventilation, except in way of widely spaced pillars and where such openings are not permitted by these Rules.

2 The number of manholes in tank tops is to be kept to the minimum compatible with securing free ventilation and ready access to all parts of the double bottom. Care is to be taken for locating the manholes to avoid the possibility of interconnection of main subdivision compartments through the double bottom so far as practicable.

3 Covers of manholes specified in **-2** are to be of steel, and where no ceiling is provided in the cargo holds, the covers and their fittings are to be effectively protected against damage by the cargo.

4 Air and drainage holes are to be provided in all non-watertight members of the double bottom structure.

5 The proposed locations and sizes of manholes and lightening holes are to be indicated in the plans submitted for approval.

6.1.3 Drainage

1 Efficient arrangements are to be provided for draining water from the tank top.

2 Regarding the application of **-1**, small wells may be constructed in the double bottom in connection with drainage arrangements. Such wells are not to extend downward more than necessary. The vertical distance from the bottom of such a well to a plane coinciding with the keel line is not to be less than $0.5h$ (h is specified in **6.1.1-1**) or 500 mm, whichever is greater, or as deemed appropriate by the Society.

3 Other wells (e.g. for lubricating oil under main engines) may be permitted by the Society if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this Chapter.

6.1.4 Cofferdams

Oiltight cofferdams are to be provided in the double bottom between tanks carrying oils and those carrying fresh water, such as for personnel use or boiler feed water, to prevent fresh water from being contaminated by oil.

6.1.5 Watertight Girders and Floors

The thickness of watertight girders and floors, and the scantlings of stiffeners attached to them are to comply with the relevant requirements for girders and floors, as well as the requirements in 14.2.2 and 14.2.3.

6.1.6 Minimum Thickness

No structural member of the double bottom construction is to be less than 6 *mm* in thickness.

6.2 Centre Girder

6.2.1 Arrangements and Construction of Centre Girders

1 Centre girders are to extend as far forward and afterward as practicable.

2 Centre girder plates are to be continuous for $0.5L$ amidships.

3 Where double bottoms are used for carriage of fuel oil, fresh water or water ballast, the centre girders are to be watertight.

4 The requirements in -3 may be suitably modified in narrow tanks at the end parts of the ship or where other watertight longitudinal girders are provided at about 0.25 B from the centre line or where deemed appropriate by the Society.

6.2.2 Lightening Holes

1 Lightening Holes may be provided on centre girders in every frame space outside 0.75 L amidships.

2 Lightening Holes may be provided on centre girders in alternate frame spaces for 0.75 L amidships, provided that the depth of the holes does not exceed one-third of the depth of the centre girder.

6.2.3 Depth of Centre Girders

The depth of the centre girders is not to be less than $B/16$ unless specially approved by the Society, but is not to be less than 700 *mm*.

6.2.4 Thickness of Centre Girder Plates

The thickness of centre girder plates is not to be less than that obtained from the following formula:

$$0.05L + 6 \ \ (mm)$$

6.2.5 Brackets

1 Where the longitudinal framing system is adopted in the double bottom, transverse brackets are to be provided between the solid floors with a spacing of not more than 1.75 *metres* connecting the centre girder plates to the bottom shell plating as well as the adjacent bottom longitudinals. Where the spacing of these brackets exceeds 1.25 *metres*, additional stiffeners are to be provided on the centre girder plates.

2 The thickness of the brackets specified in -1 is not to be less than that obtained from the following formula. However, the thickness need not be greater than that of the solid floors at the same location.

$$0.6\sqrt{L} + 2.5 \ \ (mm)$$

3 The stiffeners specified in -1 are to be flat bars having the same thickness as that of the girder plates and the depth not less than 0.08 d_0, where d_0 is the depth of the centre girder in *metres*.

6.3 Side Girders

6.3.1 Arrangement

1 Side girders in 0.5 L amidships are to be so arranged that the distance from the centre girder to the first side girder, between girders, or from the outermost girder to the margin plate does not exceed 4.6 *m*, and to extend as far afterwards as practicable.

2 In the strengthened bottom forward specified in 6.9.2 of ships, side girders and half-height girders are to be provided as required in 6.9.3.

3 Adequate strengthening is to be made under main engines and thrust seatings by means of additional full or half-height girders.

6.3.2 Thickness of Side Girders

The thickness of side girders is not to be less than that obtained from the following formula and in the engine room, the thickness is to be increased by 1.5 *mm*.

$$0.65\sqrt{L} + 2.5 \ \ (mm)$$

6.3.3 Thickness of Half-height Girders

The thickness of half-height girders is not to be less than that obtained from the formula in 6.3.2.

6.3.4 Scantlings of Vertical Stiffeners and Struts

1 Vertical stiffeners are to be provided to side girders at every open floor where the double bottom is framed transversely, or at a suitable distance where the double bottom is framed longitudinally, and vertical struts are to be provided on half-height girders at every open floor.

2 The vertical stiffeners required by **-1** are to be flat bars having the same thickness as that of the girder plates and the depth is to be not less than 0.08 d_0 (m), where d_0 is as stipulated in **6.2.5-3**.

3 The sectional area of vertical struts required by **-1** is not to be less than requirements in **6.6.3**.

6.3.5 Lightening Holes

Lightening holes in the side girder located within 10% of the length of a hold from a transverse bulkhead, are to have a diameter not more than one-third the depth of the girder. However, this requirement may be modified in exceptional short holds and outside 0.75 L amidships and where suitable compensation is made to the girder plate.

6.4 Solid Floors

6.4.1 Arrangements

1 Solid floors are to be provided at a spacing not exceeding approximately 3.5 *metres*.

2 In addition to complying with the requirements in **-1**, solid floors are to be provided at the following locations:

(1) At every frame in the main engine room
Solid floors may, however, be provided at alternate frames outside the engine seatings, if the double bottom is framed longitudinally.

(2) Under thrust seatings and boiler bearers

(3) Under transverse bulkheads

(4) At the locations specified in **6.9.3**, between the collision bulkhead and the after end of the strengthened bottom forward specified in **6.9.2**

3 Watertight floors are to be so arranged that the subdivision of the double bottom generally corresponds to that of the ship.

6.4.2 Thickness of Solid Floors

The thickness of solid floors is not to be less than that obtained from the following formulae and in the engine room, the thickness is to be increased by 1.5 *mm*.

In ships with transverse framing: $0.6\sqrt{L} + 2.5$ (mm)

In ships with longitudinal framing: $0.7\sqrt{L} + 2.5$ (mm)

6.4.3 Vertical Stiffeners

1 Vertical stiffeners are to be provided at a suitable spacing on solid floors when the double bottom is framed transversely, and at every longitudinal when the double bottom is framed longitudinally.

2 The vertical stiffeners prescribed in **-1** are to be flat bars having the same thickness as that of the floor plates and the depth is not to be less than 0.08 d_0, where d_0 is as stipulated in **6.2.5-3**.

6.4.4 Lightening Holes

Within 0.1 B from side shell plating, the diameter of lightening holes provided in the solid floors in the middle half length of a hold is not to exceed about one-fifth of the depth of floors. However, this requirement may be modified at the end parts of ship and in exceptionally short holds and where suitable compensation is made to the solid floors.

6.5 Open Floors

6.5.1 Arrangements

Where the double bottom is framed transversely, open floors are to be provided at every hold frame between solid floors in accordance with the requirements in **6.5**.

6.5.2 Scantlings of Frames and Reverse Frames

1 The section modulus of frames is not to be less than 30 cm^3 and is obtained from the following formula:

$CShl^2$ (cm^3)

Where:

l: Distance (m) between the brackets attached to the centre girder and the margin plate

Where side girders are provided, l is the greatest distance among the distance between the vertical stiffeners on side girders and the brackets. (*See* **Fig. CS6.1**)

S: Spacing (m) of frames

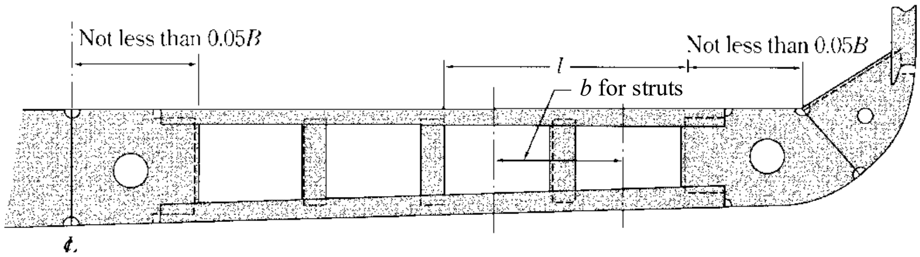
h: $d + 0.026\,L$ (m)

C: 6.0 for open floors without vertical struts as specified in **6.5.3**

4.4 for open floors under deep tanks with vertical struts as specified in **6.5.3**

2.9 for elsewhere

Fig. CS6.1 Open Floors



2 The section modulus of reverse frames is not to be less than that obtained from the formula in **-1** with C equal to 0.85 *times* the value specified for frames at the same location. Where no vertical strut is provided on the open floors under deep tanks, the section modulus of reverse frames is to be the value specified in **14.2.3**.

6.5.3 Vertical Struts

1 Vertical struts are to be rolled sections other than flat bars and bulb plates and are to sufficiently overlap the webs of frames and reverse frames.

2 The sectional area of vertical struts specified in **-1** is to be in accordance with the requirements in **6.6.3**.

6.5.4 Brackets

1 Frames and reverse frames are to be connected to the centre girder and margin plates by brackets whose thickness is not to be less than that obtained from the formula in **6.2.5-2**.

2 The breadth of brackets specified in **-1** is not to be less than 0.05 B and the brackets are to sufficiently overlap the frames and reverse frames. The free edges of the brackets are to be properly stiffened.

6.6 Longitudinals

6.6.1 Spacing

The standard spacing of longitudinals is obtained from the following formula:

$$2L + 550 \quad (mm)$$

6.6.2 Scantlings

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

$$CShl^2 \quad (cm^3)$$

Where:

l: Spacing (m) of solid floors

S: Spacing (m) of longitudinals

h: Vertical distance (m) from the longitudinals to a point of $d + 0.026\,L$ above the top of the keel

C: 8.6 for longitudinals without struts as specified in **6.6.3**

6.2 for longitudinals under deep tanks with struts as specified in **6.6.3**

4.1 for elsewhere

2 The section modulus of inner bottom longitudinals is not to be less than obtained from the formula in **-1** with *C* equal to 0.85 *times* the value specified for bottom longitudinals at the same location. Where no vertical struts is provided on the longitudinals under deep tanks, the section modulus of inner bottom longitudinals is to be the value specified in **14.2.3**.

6.6.3 Vertical Struts

1 Vertical struts are to be rolled sections other than flat bars or bulb plates and are to sufficiently overlap 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:

$$2.2Sbh \quad (cm^2)$$

Where:

S: Spacing (m) of longitudinals

b: Breadth (m) of the area supported by the strut (*See* **Fig. CS6.1**)

h: As specified in **6.6.2-1**

6.7 Inner Bottom Plating and Margin Plates

6.7.1 Thickness of Inner Bottom Plating

The thickness of the inner bottom plating is not to be less than that obtained from the following formula. Under the hatchway, if no ceiling is provided, and in the main engine room, the thickness is to be increased by 2 *mm*.

$$3.8S\sqrt{d} + 2.5 \quad (mm)$$

Where:

S: Spacing (m) of inner bottom longitudinals for longitudinally framed inner bottom plating, or spacing (m) of floor plates for transversely framed inner bottom plating

6.7.2 Ships whose Cargoes are Regularly Handled by Grabs or Similar Mechanical Appliances

In ships in which cargoes are regularly handled by grabs or similar mechanical appliances, the thickness of inner bottom plating is to be increased by 2.5 *mm* above that specified in **6.7.1**, except where a ceiling is provided.

6.7.3 Thickness of Margin Plates

The thickness of margin plates is to be increased by 1.5 *mm* above that obtained from the formula in **6.7.1**.

6.7.4 Breadth of Margin Plates

Margin plates are to be of adequate breadth and to extend well inside from the line of toes of tank side brackets.

6.7.5 Brackets

1 Where the double bottom is framed longitudinally, brackets are to be provided transversely at every hold frame extending from the margin plate to the adjacent bottom and inner bottom longitudinals and to be connected with the margin plates, shell plating and longitudinals.

2 The thickness of brackets specified in **-1** is not to be less than that obtained from the formula in **6.2.5-2**.

6.8 Tank Side Brackets

6.8.1 Tank Side Brackets

1 The thickness of brackets connecting hold frames to margin plates is to be increased by 1.5 *mm* above that obtained from the formula in **6.2.5-2**.

2 The free edges of brackets are to be properly stiffened.

3 Where the shape of the ship requires exceptionally long brackets, additional stiffness is to be provided by fitting angles longitudinally across the top of the flanges, or by other suitable means.

6.9 Construction and Strengthening of the Bottom Forward

6.9.1 Application

1 In ships having a bow draught under 0.037 L in ballast condition, the construction of the strengthened bottom forward is to be in accordance with the requirements in **6.9**.

2 In ships having an unusually small draught in the ballast condition and that have especially high speed for the ship's length, special attention is to be paid to the construction of the strengthened bottom forward.

6.9.2 Strengthened Bottom Forward

1 The part of the flat bottom forward from the position specified in **Table CS6.1** is defined as the strengthened bottom forward.

Table CS6.1 After End of Range of Strengthened Bottom Forward

$V/\sqrt{L}$	1.1 and under	1.1 1.25	1.25 1.4	1.4 1.5	1.5 1.6	1.6 1.7	greater than 1.7
The distance from the fore end of L	0.15 L	0.175 L	0.2 L	0.225 L	0.25 L	0.275 L	0.3 L

2 Notwithstanding the requirement in **-1**, ships that have an especially small draught in ballast condition or where C_b is especially small are to have the strengthened bottom forward extended to the satisfaction of the Society.

6.9.3 Construction

1 Between the collision bulkhead and 0.05 L abaft the after end of the strengthened bottom forward, full or half-height girders are to be provided in accordance with **Table CS6.2**. Where transverse framing is adopted between the collision bulkhead and 0.025 L abaft the after end of the strengthened bottom forward, half height girders or shell stiffeners are to be provided in accordance with **Table CS6.2**.

2 Between the collision bulkhead and the after end of the strengthened bottom forward, solid floors are to be provided in accordance with **Table CS6.2**.

3 The solid floors are to be strengthened by providing vertical stiffeners in way of half-height girders or longitudinal shell stiffeners, except where the longitudinal shell stiffeners are spaced especially close and the solid floors are adequately reinforced, the vertical stiffeners for the solid floors may be provided on alternate shell stiffeners.

4 In ships having a bow draught of more than 0.025 L but less than 0.037 L in ballast condition, where the construction and arrangement of the strengthened bottom forward are impracticable to comply with the requirements in **-1** and **-2**, suitable compensation is to be provided for the floors and side girders.

Table CS6.2 Construction of Strengthened Bottom Forward

Double Bottom \ Side	Members	Side Girders	Half-height Girders or Shell Stiffeners	Solid Floors
Transverse framing	Transverse framing	To be provided at intervals within 2.5 *meters*	To be provided between side girders	To be provided at every frame
	Longitudinal framing			To be provided at intervals within 2.5 *meters*
Longitudinal framing	Transverse framing	To be provided at intervals within 2.5 *meters*	—	To be provided at alternate frames
	Longitudinal framing			To be provided at intervals within 2.5 *meters*

6.9.4 Scantlings of Longitudinal Shell Stiffeners or Bottom Longitudinals

1 In ships having a bow draught of not more than 0.025 L in ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is not to be less than that obtained from the following formula:

$$0.53P\lambda l^2 \quad (cm^3)$$

Where:

l: Spacing (m) of solid floors

λ: 0.774 l

However, where the spacing (m) of longitudinal shell stiffeners or bottom longitudinals is not more than 0.774 l, λ is to be taken as the spacing.

P: Slamming impact pressure obtained from the following formula:

$$2.48\frac{LC_1C_2}{\beta}\ (kPa)$$

C_1: Coefficient given in **Table CS6.3**

For intermediate values of $V/\sqrt{L}$, C_1 is to be obtained by linear interpolation.

C_2: Coefficient obtained from following formula:

Where $\frac{V}{\sqrt{L}}$ is 1.0 and under: 0.4

Where $\frac{V}{\sqrt{L}}$ is over 1.0, but less than 1.3: $0.667\frac{V}{\sqrt{L}} - 0.267$

Where $\frac{V}{\sqrt{L}}$ is 1.3 and over: $1.5\frac{V}{\sqrt{L}} - 1.35$

β: Slope of the ship's bottom obtained from the following formula, but C_2/β need not be taken as greater than 11.43 (*See* **Fig. CS6.2**)

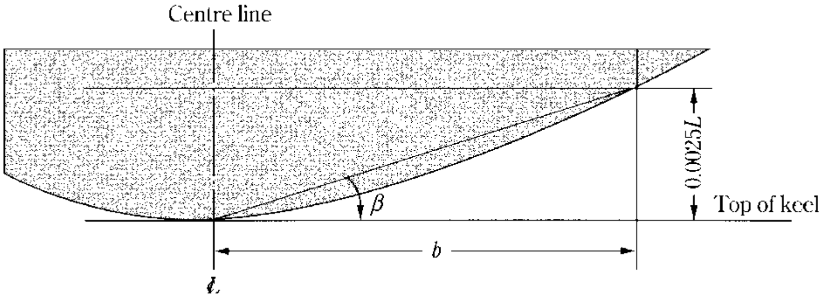
$$\frac{0.0025L}{b}$$

b: Horizontal distance (m) measured at 0.2 L from the stem, from the centre line of the ship to the intersection of the horizontal line 0.0025 L above the top of the keel with the shell plating (*See* **Fig. CS6.2**)

Table CS6.3 Value of C_1

$V/\sqrt{L}$	1.0 and under	1.1	1.2	1.3	1.4	1.5 and above
C_1	0.12	0.18	0.23	0.26	0.28	0.29

Fig. CS6.2 Measurement of b



2 In ships having a bow draught of more than 0.025 L but less than 0.037 L in ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is to be obtained by linear interpolation from the values given by the requirements in **-1** and **6.6**.

Chapter 7 FRAMES

7.1 General

7.1.1 Application

The requirements in this Chapter apply to ships having sufficient transverse strength and transverse stiffness due to bulkheads. Where transverse strength and transverse stiffness provided by bulkheads is not sufficient or the hold length is over 25 m in length, additional stiffening is to be made by means of increasing scantlings of frames, provision of web frames, etc.

7.1.2 Frames in way of Deep Tanks

The strength of frames in way of deep tanks is not to be less than required for stiffeners on deep tank bulkheads.

7.1.3 Consideration for the Tightness of Tank Tops

Frames are not to extend through the tops of water or oil tanks, unless the effective watertight or oiltight arrangements are specially submitted and approved.

7.1.4 Frames in Boiler Spaces and in way of Bossing

1 In boiler spaces, the scantlings of frames and side stringers are to be appropriately increased.

2 The construction and scantlings of frames in way of bossing are to be to the satisfaction of the Society.

7.2 Frame Spacing

7.2.1 Transverse Frame Spacing

1 The standard spacing of transverse frame is obtained from the following formula:

$$450 + 2L \ (mm)$$

2 Transverse frame spacing in peaks or cruiser sterns as well as between 0.2 L from the fore end and the collision bulkhead is not to exceed 610 mm or the standard spacing specified in **-1**, whichever is smaller.

3 The requirements in **-2** may be modified, where structural arrangement or scantlings are suitably considered.

7.2.2 Longitudinal Frame Spacing

The standard spacing of longitudinal frames is obtained from the following formula:

$$550 + 2L \ (mm)$$

7.2.3 Consideration for Frame Spacing Exceeding the Standard

Where the spacing of frames exceeds the standard spacing stipulated in **7.2.1** and **7.2.2** by at least 170 mm, special consideration is to be made for the scantlings and structural arrangement of single and double bottoms and other relevant structures.

7.3 Transverse Hold Frames

7.3.1 Application

1 Transverse hold frame is the frame provided below the lowest deck from the collision bulkhead to the after peak bulkhead, including the machinery space.

2 The application of these provisions to transverse hold frames of ships which have hopper side tanks, top side tanks, etc. or which have a special construction such as inner hulls, will be at the discretion of the Society.

7.3.2 Scantlings of Transverse Hold Frames

1 The section modulus of transverse hold frames is not to be less than that obtained from the following formula, and is not to be less than 30 cm^3.

$$CShl^2 \ (cm^3)$$

Where:

S: Frame spacing (m)

l: Vertical distance (m) from the top of inner bottom plating or single bottom floors at side to the top of deck beams above the frames

h: Vertical distance (m) from the lower end of the hold frame to a point $\{d + 0.044L - 0.54\}$ above the top of the keel

C: Coefficient obtained from the following formulae:

For frames between 0.15 L from the fore end and the after peak bulkhead: 2.6

For frames between 0.15 L from the fore end and the collision bulkhead: 3.4

2 For the frames under transverse web beams supporting deck longitudinals, the section modulus is to be in accordance with the requirements in **-1**, and additionally, it is not to be less than that obtained from the following formula:

$$2.4n\left[0.17 + \frac{1}{9.81}\frac{h_1}{h}\left(\frac{l_1}{l}\right)^2 - 0.1\frac{l}{h}\right]Shl^2 \ \ (cm^3)$$

Where:

n: Ratio of transverse web beam spacing to frame spacing

h_1: Deck load (kN/m^2) stipulated in **17.1** for the deck beam at the top of the frame

l_1: Total length (m) of the transverse web beam

S, h and l: Values stipulated in **-1**

3 Where the depth of the bottom centre girder is less than $B/16$, the scantlings of frames are to be suitably increased.

7.3.3 Connection of Transverse Hold Frames

1 Transverse hold frames are to be overlapped with heel brackets by at least 1.5 *times* the depth of frame sections and are to be effectively connected thereto.

2 The upper ends of transverse hold frame are to be effectively connected by brackets with the deck or deck beams, and where the deck at the top of frames is longitudinally framed, the upper end brackets are to be extended and connected to the deck longitudinals adjacent to the frames.

7.4 Side Longitudinals and Other Structural Members

7.4.1 Side Longitudinals

1 The section modulus of side longitudinals in the midship part below the freeboard deck is not to be less than that obtained from the following formulae, whichever is greater, and is not to be less than 30 cm^3.

$8.6Shl^2$ (cm^3)

$2.9\sqrt{L}Sl^2$ (cm^3)

Where:

S: Spacing (m) of longitudinals

l: Distance (m) between the web frames or between the transverse bulkhead and the web frame including the length of connection

h: Vertical distance (m) from the longitudinals to a point $\{d + 0.044L - 0.54\}$ above the top of the keel

2 Beyond the midship part, the section modulus of side longitudinals may be gradually reduced towards the ends of the ship, and may be 0.85 *times* that obtained from the formula in **-1** at the ends. However, the section modulus of side longitudinals between 0.15 L from the fore end and the collision bulkhead is not to be less than obtained from the formula in **-1**.

3 The depth of flat bars used for longitudinals is not to exceed 15 *times* the thickness of flat bars.

4 Side longitudinals on sheer strakes in the midship part are to be of a slenderness ratio not greater than 60.

5 The section modulus of bilge longitudinals need not exceed that required for bottom longitudinals.

7.4.2 Web Frames

1 The web frames supporting side longitudinals are to be arranged at an interval not exceeding 4.8 m at sections where solid floors are provided.

2 The scantlings of web frames are not to be less than that obtained from the following formulae:

Depth: 0.1 l (m) or 2.5 *times* the depth of the slots for longitudinals, whichever is greater

Section modulus: C_1Shl^2 (cm^3)

Thickness of web: $\frac{C_2}{1000}\frac{Shl}{d_1}+2.5\ (mm)$

Where:

S: Web frame spacing (m)

l: Vertical distance (m) from the top of inner bottom plating or single bottom floors at side to the deck at the top of web frames

However, where there are effective deck transverses, l may be measured up to the lower surface of such transverses

d_1: Depth (m) of web frames

However, the depth of slots for side longitudinals is to be deducted from the web depth.

h: Vertical distance (m) measured from the lower end of l to a point $\{d + 0.044L - 0.54\}$ above the top of the keel

The distance is not to be less than 1.43 l.

C_1 and C_2: Coefficients as defined in **Table CS7.1**

Table CS7.1 Coefficients C_1 and C_2

	Backward of 0.15 L abaft the fore end	Between 0.15 L from the fore end and collision bulkhead
C_1	4.7	6.0
C_2	45	58

3 Web frames are to be provided with tripping brackets at an interval of about 3 m and stiffeners are to be provided on the webs at each longitudinal except for the middle part of the span of web frames where they may be provided at alternate longitudinals.

7.5 Tween Deck Frames

7.5.1 General

1 The scantlings of tween deck frames are to be determined in relation to the strength of hold frames, the arrangement and transverse stiffness of bulkheads, etc.

2 In the design of tween deck framing, considerations are to be given in conjunction with hold frames to the continuity of strength in the framing from the bottom to the top of the hull.

3 The provisions in **7.5** are based on the standard structural arrangement so as to maintain transverse stiffness of the ship by means of efficient tween deck bulkheads provided above the hold bulkheads or by web frames extended to the top of superstructures at proper intervals.

7.5.2 Scantlings of Tween Deck Frames

1 The section modulus of tween deck frames is not to be less than that obtained from the following formula:

$CSlL\ (cm^3)$

Where:

S: Frame spacing (m)

l: Tween deck height (m)

However, the height is to be taken as 1.8 m where it is less than 1.8 m for superstructure frames and as 2.15 m where the height is less than 2.15 m for others, respectively.

C: Coefficient given in **Table CS7.2**

2 The scantlings of tween deck frames below the freeboard deck within 0.125 L from the fore and after ends are to be appropriately increased above those given by **-1**.

3 Where decks are supported by longitudinal beams and transverse strong beams, the section modulus of tween deck strong frames which support beams is not to be less than that given by **-1** and **-2** multiplied by the coefficient obtained from the following formula. In this case, the section modulus of tween deck frames between strong frames is not to be less than 0.85 *times* that given by **-1** and **-2** and the upper ends are to be connected with brackets.

$1+0.2n$

Where:

n: Number of tween deck frames between web frames

Table CS7.2 Coefficient C

Description of tween deck frames	C
Superstructure frames (excluding the following two lines)	0.44
Superstructure frames for 0.125 L from after end of ship	0.57
Superstructure frames for 0.125 L from fore end and cant frames at stern	0.74
Tween deck frames between the freeboard deck and the second deck	0.74
Tween deck frames between the second deck and the third deck	0.89
Tween deck frames between the third deck and the fourth deck	0.97

7.5.3 Special Precautions Regarding Tween Deck Frames

1 Care is to be taken so that the strength and stiffness of framing at the ends of ship may be increased in proportion to the actual unsupported length of frame as well as the vertical height of tween decks.

2 In ships having an especially large freeboard, the scantlings of tween deck frames may be properly reduced.

7.5.4 Superstructure Frames

1 Superstructure frames are to be provided on every frame located below.

2 Notwithstanding the requirements in **7.5.2**, superstructure frames for four frame spaces at the ends of bridges and of detached superstructures within 0.5 L amidships are to be of the section modulus obtained from the formula in **7.5.2** using 0.74 as the coefficient C.

3 Web frames or partial bulkheads are to be provided above the bulkheads required by **Chapter 13** or at other positions such as may be considered necessary to give effective transverse rigidity to the superstructures.

7.6 Frames in Fore and After Peaks

7.6.1 Transverse Frames in Fore Peaks

The section modulus of transverse frames forward of the collision bulkhead is not to be less than that obtained from the following formula, and is not to be less than 30 cm^3.

$8Shl^2 \quad (cm^3)$

Where:

S: Frame spacing (m)

l: Distance (m) between the supports of transverses, but to be taken as 2 m where the height is less than 2 m

h: Vertical distance (m) from the midpoint of l to a point 0.12 L above the top of the keel

7.6.2 Longitudinal Frames in Fore Peaks

The section modulus of longitudinals below the freeboard deck forward of the collision bulkhead is not to be less than that obtained from the following formula. However, the modulus obtained from the formula is to be increased by 25% (between 0.05 D and 0.15 D from the top of the keel) and 50% (below 0.05 D from the top of the keel).

$8Shl^2 \quad (cm^3)$

Where:

S and l: As specified in **7.4.1**

h: Vertical distance (m) from the longitudinals to a point 0.12 L above the top of the keel, but is not to be less than 0.06 L (m)

7.6.3 Transverse Frames in After Peaks

The section modulus of transverse frames below the freeboard deck abaft the after peak bulkhead is not to be less than that obtained from the following formula, and is not to be less than 30 cm^3:

$8Shl^2 \quad (cm^3)$

Where:

S: Frame spacing (m)

l: As specified in **7.3.2**, but to be taken as 2 m where the height is less than 2 m

h: Vertical distance (m) from the midpoint of l to a point $\{d + 0.044\ L - 0.54\}$ above the top of the keel

Chapter 8 CANTILEVER BEAM CONSTRUCTION

8.1 Cantilever Beams

8.1.1 Construction and Scantlings

Cantilever beams are to comply with the requirements in **(1)** to **(7)**:

(1) The depth of cantilever beams measured at the toe of end brackets at side is not to be less than one-fifth of the horizontal distance from the inboard end of the cantilever beam to the toe of the end bracket at side.

(2) The depth of cantilever beams may be gradually tapered from the toe of end brackets towards the inboard end where it may be reduced to about a half of the depth at the toe of the end bracket.

(3) The section modulus of cantilever beams at the toe of end brackets is not to be less than that obtained from the following formula: (*see* **Fig. CS8.1**)

$$7.1Sl_0\left(\frac{1}{2}b_1h_1 + b_2h_2\right) \ (cm^3)$$

Where:

S: Cantilever beam spacing (m)

l_0: Horizontal distance (m) from the inboard end of cantilever beams to the toe of end brackets

b_1: Horizontal distance (m) from the inboard end of cantilever beams to the toe of end brackets of beam or transverse deck girder at side

However, where the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, b_1 is to be taken as l_0.

b_2: A half of the breadth (m) of the hatch opening in the deck supported by the cantilever beams

h_1: Deck load (kN/m^2) stipulated in **17.1** for the deck transverses supported by the cantilever beams

h_2: Load (kN/m^2) on hatch covers of the deck supported by the cantilever beams which is not to be less than obtained from the following **(a)** to **(c)**, depending on the type of deck:

(a) For weather decks, h_2 is the deck load (kN/m^2) stipulated in **17.1.1-2** for the deck transverses or the maximum design cargo weight on hatches per unit area (kN/m^2), whichever is greater. The value of y in **17.1.1-2(1)** may be taken as the vertical distance from the designed maximum load line to the upper edge of the hatch coaming. In either case, h_2 is not to be less than 17.5 (kN/m^2) for hatches at Position I and 12.8 (kN/m^2) for those at Position II specified in **Chapter 19**, respectively.

(b) For decks other than the weather deck where ordinary cargoes or stores are intended to be carried, h_2 is the deck load stipulated in **17.1.1-1**.

(c) For decks other than those specified in **(a)** or **(b)** above, h_2 is the value equal to h_1.

(4) The sectional area of face plates of cantilever beams may be gradually tapered from the inner edge of end brackets toward the inboard end of cantilever beams, where it may be reduced to 0.60 *times* that at the inner edge of the end brackets.

(5) The web thickness of cantilever beams at any point is not to be less than the greater of the values obtained from the following formulae:

$$t_1 = 0.0095\frac{S(\frac{1}{2}b_1h_1 + b_2h_2)}{d_c} + 2.5 \ (mm)$$

$$t_2 = 7.5d_c + 0.46t_1 + 1.5 \ (mm)$$

Where:

S, b_1, b_2, h_1 and h_2: As stipulated in **(3)**

However, where the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, $b_1/2$ is to be substituted by the horizontal distance in *metres* from the inboard end of cantilever beams to the section under consideration in the formula for t_1.

d_c: Depth (m) of the cantilever beam at the section under consideration

However, in the calculation of t_1, the depth of slots for deck longitudinals, if any, is to be deducted from the depth of cantilever beams. Where the webs are provided with horizontal stiffeners, the divided web depth may be used for d_c in the formula for t_2.

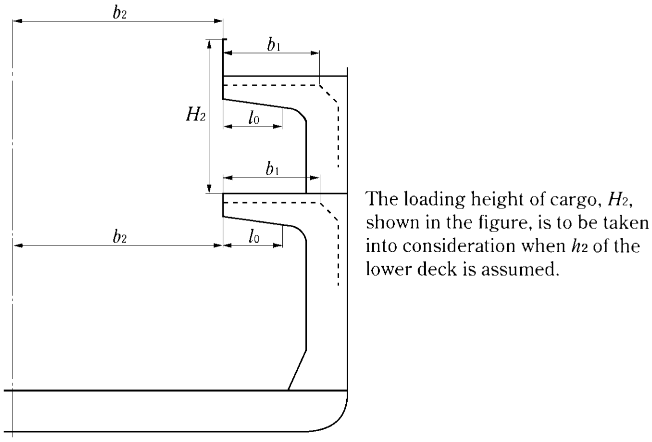
(6) Cantilever beams are to be provided with tripping brackets at an interval of about 3 m. Moreover, stiffener is to be provided on the webs at every longitudinal in the root of cantilever beams and at alternate longitudinals elsewhere.

(7) Cantilever beams supporting hatch covers on lower decks are to comply with the requirements in **(a)** and **(b)**:

(a) The leg length of the fillet welds between webs and hatch side girders is to be $F1$.

(b) Where the stiffeners are provided to prevent web plates from buckling, consideration is to be given to the arrangement of the ends of such stiffeners to ensure that there are no stress concentrations at the connections between web plates and the members supporting hatch covers on lower decks.

Fig. CS8.1 Measurement of l_0, b_1, b_2, and H_2



8.2 Web Frames

8.2.1 Construction and Scantlings

The web frames supporting cantilever beams are to comply with the requirements in **(1)** to **(7)**.

(1) The depth of web frames is not to be less than one-eighth of the length including the length of connections at both ends.

(2) The section modulus of web frames is not to be less than that obtained from the following formula. However, where a tween deck web frame in association with a cantilever beam supporting the deck above is provided at the top of the web frame, the value of the formula may be reduced to 60%.

$$7.1Sl_1(\frac{1}{2}b_1h_1+b_2h_2)\ (cm^3)$$

Where:

S: Web frame spacing (m)

l_1: Horizontal distance (m) from the end of supported cantilever beams to the inside of web frames

b_1, b_2, h_1 and h_2: As stipulated in **8.1.1(3)** for the supported cantilever beams

However, where the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, l_1 is to be substituted for b_1.

(3) The section modulus of tween deck web frames is to be in accordance with the requirements in **(2)**, and is not to be less than that obtained from the following formula:

$$7.1C_1Sl_1(\frac{1}{2}b_1h_1+b_2h_2)\ (cm^3)$$

Where:

S, l_1, b_1, b_2, h_1 and h_2: As stipulated in **(2)**

C_1: Coefficient obtained from the following formula:

$$0.15+0.5\frac{\frac{1}{2}b'_1h'_1+b'_2h'_2}{\frac{1}{2}b_1h_1+b_2h_2}$$

b'_1, b'_2, h'_1 and h'_2: b_1, b_2, h_1 and h_2 respectively stipulated in **(2)** in respect to the cantilever beams provided below the web frames concerned.

(4) The web thickness is not to be less than that obtained from the following formulae, whichever is greater:

$$t_1=0.0095\frac{C_2S(\frac{1}{2}b_1h_1+b_2h_2)}{d_w}\frac{l_1}{l}+2.5\ \ (mm)$$

$$t_2=7.5d_w+0.46t_1+1.5\ \ (mm)$$

Where:

S, b_1, b_2, h_1, h_2 and l_1: As stipulated in **(2)**

d_w: The smallest depth (m) of web frame

However, in the calculation of t_1, the depth of slots for side longitudinals, if any, is to be deducted from the web depth. Where the depth of webs is divided by vertical stiffeners, the divided depth may be used for d_w in the calculation of t_2.

l: Length (m) of web frames including the length of connections at the both ends

C_2: Coefficient given below, where C_1 is as given by **(3)**

For hold web frames:

Where a web frame in association with a cantilever beam supporting the deck above is provided directly above: 0.9

Elsewhere: 1.5

For tween deck web frames: $C_1+0.6$

(5) Where the web frames supporting cantilever beams also support side longitudinals or side stringers, the scantlings are to comply with the following requirements in addition to those in 7.4.2.

(a) The section modulus is not to be less than that obtained from the formula in **(2)**, multiplied by the following coefficient:

Where tween deck web frame together with cantilever beam is provided above:

$$0.6+9.81\frac{0.05hl^2+0.09h_ul_u{}^2}{1.4(\frac{1}{2}b_1h_1+b_2h_2)l_1}$$

Elsewhere: 1.0

Where:

l: Length (m) of hold web frames including the length of end connections

l_u: Length (m) of tween deck web frames provided directly above, including the length of connections at both ends

h: Vertical distance (m) from the middle of l to a point $d+0.038\,L$ above the top of the keel

h_u: Vertical distance (m) from the middle of l_u to a point to which h is measured

However, where the point is below the middle of l_u, h_u is to be taken as zero.

b_1, b_2, h_1, h_2 and l_1: As given by **(2)**

(b) The web thickness is not to be less than that given by **(4)**, in which the value of t_1 is to be increased by the amount obtained from the following formula:

$$0.03\frac{Shl}{d_w}\ (mm)$$

Where:

S: Web frame spacing (m)

h and l: As stipulated in **(a)** above

d_w: As stipulated in **(4)**

(6) Tripping brackets are to be provided on the webs at an interval of about 3 m, and stiffeners are to be provided on the webs at every side longitudinal at the ends of frames and at alternate longitudinals elsewhere.

(7) Web frames are to be effectively connected with other web frames located beneath or bottom floors so as to maintain strength

continuity.

8.3 Connection of Cantilever Beams to Web Frames

Cantilever beams and web frames supporting them are to be effectively connected by brackets required in **(1)** to **(4)**.

(1) The radius of curvature of the free edges of brackets is not to be less than the depth of cantilever beams at the toes of brackets.

(2) The thickness of brackets is not to be less than that of the webs of cantilever beams or web frames, whichever is the greater.

(3) The brackets are to be sufficiently strengthened by stiffeners.

(4) The free edges of brackets are to have face plates of a sectional area not less than that of cantilever beams or web frames, whichever is the greater, and the face plates are to be connected with those of cantilever beams and web frames.

Chapter 9 ARRANGEMENTS TO RESIST PANTING

9.1 General

9.1.1 Application

1 The requirements in this Chapter apply to the bottom and the side constructions in way of both peaks.

2 The side frames are to be in accordance with the requirements in **Chapter 7**.

9.1.2 Swash Plates

In fore and after peaks to be used as deep tanks, effective swash plates are to be provided at the centre line of the ship or the scantlings of structural members are to be suitably increased.

9.1.3 Stringers Fitted to Shell at Extremely Small Angles

Where the angle between the web of stringers and the shell plating is extremely small, the scantlings of stringers are to be suitably increased above the normal requirements and where necessary, appropriate supports are to be provided to prevent tripping.

9.2 Arrangements to Resist Panting Forward of Collision Bulkhead

9.2.1 Arrangement and Construction*

1 A deep centre girder or centreline longitudinal bulkhead is to be provided in the forward direction of the collision bulkhead.

2 In fore peaks constructed of transverse framing, floors having sufficient height are to be arranged at every frame and they are to be supported by the side girders provided at an interval not exceeding about 2.5 m. Frames are to be supported by the constructions specified in **9.2.2-5** to **-7** at intervals about 2.5 m.

3 In fore peaks of longitudinal framing, bottom transverse supporting bottom longitudinals and side transverse supporting side longitudinals are to be arranged at intervals about 2.5 m. Bottom transverses and side transverses are to be supported by side girders and side stringers, or cross tie provided at intervals about 4.6 m, respectively. And side transverses and bottom transverses are to be effectively connected to each other.

9.2.2 Transverse Framing Systems

1 The thickness of floors and centre girders are not to be less than that obtained from the following formula:

$0.045L + 5.5 \ (mm)$

2 The floors are to be of adequate depth and to be properly stiffened with stiffeners as may be required.

3 The upper edges of the floors and centre girders are to be properly stiffened.

4 The thickness of side girder is to be approximately equal to that of centre girders, and side girders are to extend to appropriate heights proportionate to those of the floors.

5 Where the panting beams are provided at every frame and the beams are covered with perforated steel plates from one side of the ship to the other side, the scantlings of panting beams and steel plates are not to be less than that obtained from the following formulae:

Sectional area of panting beams: $0.1\ L + 5\ (cm^2)$

Thickness of steel plates: $0.02\ L + 5.5\ (mm)$

6 Where the side stringers are provided, their scantlings are not to be less than that obtained from the following formulae:

Web depth: $0.2\ l\ (m)$, 2.5 *times* the depth of slots for transverse frames or the value obtained from the following formula, whichever is the greatest.

$0.0053L + 0.25 \ (m)$

Section modulus: $8\ Shl^2\ (cm^3)$

Web thickness: $0.02\ L + 6.5\ (mm)$

where:

S: Breadth (m) of area supported by the side stringer.

h: Vertical distance (m) from the centre of S to a point of $0.12\ L\ (m)$ above the top of keel

However, where h is less than that 0.06 $L(m)$, h is to be taken as 0.06 $L(m)$.

l: Horizontal distance (m) between the supporting points of side stringers.

7 Where panting beams are provided at alternate frames together with stringer plates connected to the shell plating, the scantling of panting beams and stringer plates are to comply with following requirements.

(1) The sectional area of panting beams is not to be less than that obtained from the following formula:

$0.3L$ (cm^2)

(2) The scantlings of stringer plates are not to be less than that obtained from the following formulae:

Breadth: 5.3 L + 250 (mm)

Thickness: 0.02 L + 6.5 (mm)

9.2.3 Longitudinal Framing

1 Where the bottom transverses are supported along the centre line, their scantlings are not to be less than that obtained from the following formulae:

Web depth: 0.2 l (m) or 0.0085 L + 0.18 (m), whichever is greater.

Section modulus: 1.2 SLl^2 (cm^3)

Web thickness: $0.005\dfrac{SLl}{d_1}+2.5$ (mm), or $4+0.6\sqrt{L}$ (mm), whichever is greater.

where:

S: Spacing (m) of transverses.

l: Length (m) of transverses between the supporting points.

d_1: Depth (m) of transverses subtracted by the depth of slot for longitudinals.

2 The scantlings of centre girders are not to be less than those of bottom transverses specified in **-1**.

3 The scantlings of side transverses supporting longitudinals are not to be less than that obtained from the following formulae:

Web depth: 0.2 l_0 (m), 0.0053 L + 0.25 (m) or 2.5 times the depth of slots for longitudinals (m), whichever is the greatest.

Section modulus: $8Shl_0^2$ (cm^3)

Web thickness: $0.042\dfrac{Shl_0}{d_1}+2.5$ (mm) or 0.02 L + 6.5 (mm), whichever is greater.

where:

S: Spacing (m) of transverses.

d_1: As specified in **-1**.

h: Vertical distance (m) from the centre of l_0 to a point of 0.12 L (m) above the top of keel

However, where h is less than that $0.06L(m)$, h is to be taken as 0.06 L (m).

l_0: Length (m) of side transverses between the supporting points.

4 Side transverses are to be provided with tripping brackets at intervals not exceeding about 3 m and stiffeners are to be provided on the webs at every longitudinal.

5 The scantlings of side stringers which support side transverses are not to be less than that obtained from the following formulae:

Web depth: 0.2 l_1 (m) or 0.0053 L + 0.25 (m) whichever is greater.

Section modulus: 4 Shl_0l_1 (cm^3)

Web thickness: $0.031\dfrac{Shl_1}{d_1}+2.5$ (mm) or 0.02 L + 6.5 (mm), whichever is greater.

where:

S: Breadth (m) of area supported by the stringer.

h: Vertical distance (m) from the centre of S to a point of 0.12 L (m) above the top of keel

However, where h is less than that 0.06 L (m), h is to be taken as 0.06 L (m).

l_0: As stipulated in **-3**.

l_1: Length (m) of side stringers.

d_1: Depth (m) of side stringers subtracted by the depth of slot.

6 The scantlings of cross ties supporting the side transverses are not to be less than that obtained from the following formulae:

Sectional area:

Where l/k is 0.6 and above: $\frac{0.77Sbh}{1-0.5(l/k)}$ (cm^2)

Where l/k is less than 0.6: $1.1Sbh$ (cm^2)

where:

S: Spacing (m) of transverses.

b: Breadth (m) of area supported by the cross ties.

h: Vertical (m) distance from the centre of b to a point of 0.12 L (m) above the top of keel

However, where h is less than that 0.06 L (m), h is to be taken as 0.06L (m).

l: Length (m) of cross ties.

k: $\sqrt{\frac{I}{A}}$

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

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

(1) Cross ties are to be effectively connected to the transverses by brackets or other suitable arrangements and the transverses are to be provided with tripping brackets in way of the cross ties.

(2) Where the breadth of face plate of cross ties on either side of the web exceeds 150 mm, stiffeners are to be provided on the webs and so arranged as to support the face plate at suitable interval.

9.3 Arrangements to Resist Panting abaft of After Peak Bulkhead

9.3.1 Floors

The requirements in 9.2.2 apply to the scantlings and arrangement of floors in the after peak.

9.3.2 Frames

Where the distance between the supports at any part of the girth of frames exceeds 2.5 m, the scantlings of frames are to be increased, or side stringers or struts are to be additionally provided to give adequate stiffness to the side structure.

9.3.3 Other Construction Members

Where the constructions in after peak are in compliance with the requirements for fore peak in 9.2, the scantlings of transverses, stringers, and struts are to be 0.67 *times* the values specified in 9.2.

Chapter 10 BEAMS

10.1 General

10.1.1 Camber of Weather Deck

The standard camber of weather deck is B/50 at midship.

10.1.2 Connections of Ends of Beams

1 Longitudinal beams are to be continuous or to be connected with brackets at their ends in such a manner as to effectively uphold the sectional area and to have sufficient strength to withstand bending and tension.

2 Transverse beams are to be connected to frames by brackets.

3 Transverse beams provided at positions where frames are omitted in tween decks or superstructures, are to be connected to the side plating by brackets.

4 Transverse beams on decks (boat decks, promenade decks, etc.) may be connected at their ends by clips.

10.1.3 Transition from Longitudinal Beam to Transverse Beams System

Special care is to be taken to keep the continuity of strength in parts where longitudinal beam system changes to a transverse beam system.

10.2 Longitudinal Beams

10.2.1 Spacing

The standard spacing of longitudinal beams is obtained from the following formula:

$2L + 550$ (mm)

10.2.2 Proportion

1 Longitudinal beams are to be supported by deck transverses of appropriate spacing. The slenderness ratio of deck longitudinals in the strength deck of the midship part is not to exceed 60. However, this requirement may be suitably modified where longitudinal beams are given sufficient strength to prevent buckling.

2 Flat bars used for longitudinals are not to be of a depth-thickness ratio exceeding 15.

10.2.3 Section Modulus of Longitudinal Beams

1 The section modulus of longitudinal beams outside the line of openings of the strength deck for the midship part is not to be less than that obtained from the following formula:

$1.14Shl^2$ (cm^3)

Where:

S: Spacing (m) of longitudinal beams

h: Deck loads (kN/m^2) specified in **17.1**

l: Horizontal distance (m) between bulkhead and deck transverse or between deck transverses

2 The coefficient in formula in **-1** may be gradually reduced for longitudinal beams outside the line of openings of the strength deck for parts forward and afterward of the midship part. However, the section modulus is not to be less than that obtained from the following formula:

$0.43Shl^2$ (cm^3)

Where:

S, h and l:As specified in **-1**

3 The section modulus of longitudinal beams for parts other than those stipulated in **-1** and **-2** is not to be less than that obtained from the formula in **-2**.

10.2.4 Deck Transverses Supporting Longitudinal Beams

In single deck ships, the deck transverse are to be provided in line with the solid floors in the bottom. In two deck ships, the transverses are also to be provided in line with the solid floors in the double bottom as far as is practicable.

10.3 Transverse Beams

10.3.1 Arrangement of Transverse Beams

Transverse beams are to be provided on every frame.

10.3.2 Proportion

It is preferable that the length/-depth ratio of transverse beams be 30 or less at the strength deck, and 40 or less at effective decks (the decks below the strength deck which are considered as strength members in the longitudinal strength of the hull) and superstructure decks as far as practicable.

10.3.3 Section Modulus of Transverse Beams

The section modulus of transverse beams is not to be less than that obtained from the following formula:

$0.43Shl^2$ (cm^3)

Where:

S: Spacing (m) of transverse beams

h: Deck load (kN/m^2) specified in **17.1**

l: Horizontal distance (m) from the inner edge of beam brackets to the longitudinal deck girder, or between the longitudinal deck girders

10.4 Beams on Bulkhead Recesses and Others

10.4.1 Section Modulus

The section modulus of beams at deck forming the top of bulkhead recesses, tunnels and tunnel recesses is not to be less than that obtained from the formula in **13.2.7**.

10.5 Beams on top of Deep Tanks

10.5.1 Section Modulus

The section modulus of beams at deck forming the top of deep tanks is to be in accordance with this Chapter, and not to be less than that obtained from the formula in **14.2.3**, taking the top of deck beams as the lower end of h and beams as stiffeners.

10.6 Deck Beams Supporting Especially Heavy Loads

10.6.1 Reinforcement of Deck Beams

The deck beams supporting especially heavy loads or arranged at the ends of superstructures or deckhouses, in way of masts, winches, windlasses and auxiliary machinery, etc. are to be properly reinforced by increasing the scantlings of the beams, or by the addition of deck girders or pillars.

10.7 Deck Beams Supporting Vehicles

10.7.1 Section Modulus of Beams

The section modulus of beams of decks loaded with wheeled vehicles is to be determined by considering the concentrated loads from the wheeled vehicles.

10.8 Deck Beams Supporting Unusual Cargoes

10.8.1 Section Modulus of Beams

The section modulus of beams of decks carrying cargo loads which can not be treated as evenly distributed loads is to be determined by taking into account the load distribution of each particular cargo.

Chapter 11 PILLARS

11.1 General

11.1.1 Tween Deck Pillars

Tween deck pillars are to be arranged directly above those in the holds, or effective means are to be provided for transmitting their loads to the supports below.

11.1.2 Pillars in Hold

Pillars in hold are to be provided in line with the single or double bottom girders or as close thereto practicable, and the structures above and under where the pillars are connected are to be of ample strength to provide effective distribution of the load.

11.1.3 End Connection of Pillars

The head and heel of pillars are to be secured by thick doubling plates and brackets as necessary. For pillars which may be subject to tensile loads in locations such as under bulkhead recesses, tunnel tops or deep tank tops, the head and heel of the pillars are to be efficiently secured to withstand these loads.

11.1.4 Reinforcement of Structures Connected to Pillars

Where the pillars are connected to the deck plating, the top of shaft tunnels, or the frames, those structures are to be efficiently strengthened.

11.2 Scantlings

11.2.1 Sectional Area of Pillars

The sectional area of pillars is not to be less than that obtained from the following formula:

$$\frac{0.223w}{2.72-\frac{l}{k_0}} \ (cm^2)$$

Where:

l: Distance (m) from the top of inner bottom, deck or other structures on which the pillars are based to the underside of beam or girder supported by the pillars (*See* **Fig. CS11.1**)

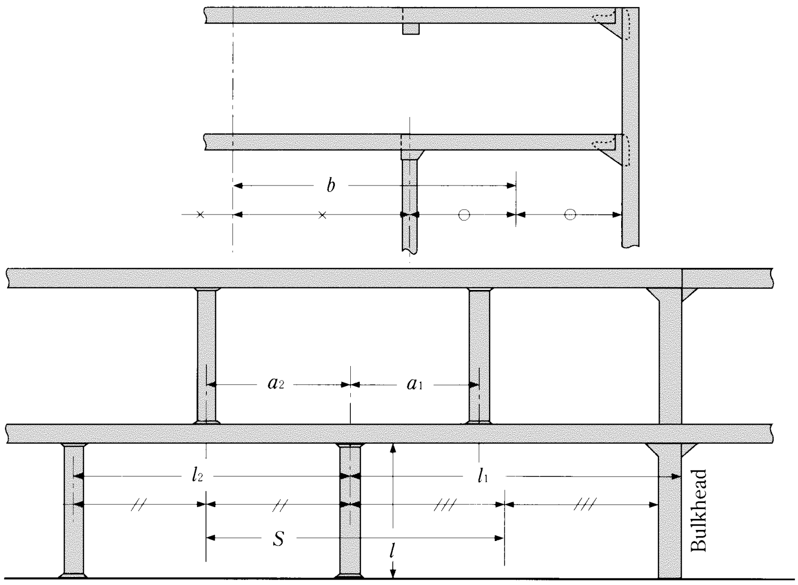
$$k_0 = \sqrt{\frac{I}{A}}$$

I: The least moment of inertia (cm^4) of the pillar

A: Sectional area (cm^2) of the pillar

w: Deck load (kN) supported by pillars as specified in **11.2.2**

Fig. CS11.1 Measurement of S, b, l, etc.



11.2.2 Deck Load Supported by Pillars

1 Deck load w supported by pillars is not to be less than that obtained from the following formula:

$kw_0 + Sbh$ (kN)

Where:

S: Distance (m) between the mid-points of two adjacent spans of girders supported by the pillars or the bulkhead stiffeners or bulkhead girders. (*See* **Fig. CS11.1**)

b: Mean distance (m) between the mid-points of two adjacent spans of beams supported by the pillars or the beam brackets. (*See* **Fig. CS11.1**)

h: Deck load (kN/m^2) specified in **17.1** for the deck under consideration

w_0: Deck load (kN) supported by the upper tween deck pillar

k: As obtained from the following formula:

$$2\left(\frac{a_i}{l_j}\right)^3 - 3\left(\frac{a_i}{l_j}\right)^2 + 1$$

a_i : Horizontal distance (m) from the pillars to the tween deck pillars above

l_j : Span (m) of girder supporting the tween deck pillar or bulkhead (*See* **Fig.CS11.1**)

2 Where there are two or more tween deck pillars provided on the deck girder supported by a line of lower pillars, the lower pillars are to be of the scantling required in **-1**, taking kw_0 for each tween deck pillar provided on two adjacent spans supported by the lower pillars.

3 Where tween deck pillars are located athwartships from the lower pillars, the scantlings of the lower pillars are to be determined by applying the same principles as in **-1** and **-2**.

4 The load supported by pillars of decks carrying cargoes which can not be treated as evenly distributed loads is to be determined by taking into account the load distribution of each particular cargo. Where cargo loads can be treated as concentrated loads acting on specific points, the provisions of **-1** and **-2** above may be applied so that such concentrated loads are treated as deck loads supported by the upper tween deck pillars (w_0).

11.2.3 Thickness of Plates

1 The plate thickness of tubular pillars is not to be less than that obtained from the following formula:

$0.022d_p + 4.6$ (mm)

Where:

d_p: Outside diameter (mm) of the tubular pillar.

However, this requirement may be suitably modified for pillars provided in accommodation spaces.

2 The thickness of web and flange plate of built-up pillars is to be sufficient for the prevention of local buckling.

11.2.4 Outside Diameters of Round Pillars

The outside diameter of solid round pillars and tubular pillars is not to be less than 50 mm.

11.2.5 Pillars Provided in Deep Tanks

1 Pillars provided in deep tanks are not to be tubular pillars.

2 The sectional area of pillars is not to be less than that specified in **11.2.1** or obtained from the following formula:

$1.09Sbh \ (cm^2)$

Where:

S and b: As specified in **11.2.2-1**.

h: 0.7 times the vertical distance (m) from the top of the deep tank to the point of 2.0 *metres* above the top of the overflow pipe (m).

11.3 Bulkheads in lieu of Pillars

11.3.1 Construction

The transverse bulkheads supporting longitudinal deck girders and the longitudinal bulkheads provided in lieu of pillars are to be stiffened in such a manner as to provide supports not less effective than that required for pillars.

11.4 Casing provided in lieu of Pillars

11.4.1 Construction

The casings provided in lieu of pillars are to be of sufficient scantlings to withstand the deck load and side pressure.

Chapter 12 DECK GIRDERS

12.1 General

12.1.1 Application

Transverse deck girders supporting longitudinal deck beams and longitudinal deck girders supporting transverse deck beams are to be in accordance with the requirements in this Chapter.

12.1.2 Arrangement

In way of the bulkhead recesses and the top of tanks, deck girders are to be arranged at intervals not exceeding 4.6 *metres* as far as practicable.

12.1.3 Construction

1 Deck girders are to be composed of face plates provided along the lower edge.

2 Tripping brackets are to be provided at intervals of about 3 *metres* and where the breadth of face plates exceeds 180 *mm* on either side of the girder, these brackets are to be so arranged as to support the face plates as well.

3 The thickness of face plates forming girders 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:

$$85.4\sqrt{d_0 l}\ (mm)$$

Where:

d_0 : Depth (m) of girders

l : Distance (m) between the supports of girders

However, if effective tripping brackets are provided, they may be taken as supporting points.

4 The depth of girders between bulkheads is to be kept constant between two adjacent bulkheads, and not to be less than 2.5 *times* that of the slots for beams.

5 The girders are to have sufficient rigidity to prevent excessive deflection of decks and excessive additional stresses in deck beams.

12.1.4 End Connection

1 End connections of deck girders are to be in accordance with the requirements in **1.3.4**.

2 Bulkhead stiffeners or girders at the ends of deck girders are to be suitably strengthened to support deck girder.

3 Longitudinal deck girders are to be continuous or to be effectively connected so as to maintain the continuity at ends.

12.2 Longitudinal Deck Girders

12.2.1 Section Modulus of Girders

1 The section modulus of longitudinal deck girders outside the lines of hatchway openings of the strength deck for the midship part is not to be less than that obtained from the following formula:

$$1.29l(lbh + kw)\ (cm^3)$$

Where:

l: Distance (m) between the centres of pillars or from the centre of the pillar to the bulkhead

Where deck girders are fixed to the bulkhead by effective brackets, l may be modified as specified in **1.3.6**. (*See* **Fig. CS12.1**)

b: Distance (m) between the centres of two adjacent spans of beams supported by girders or frames (*See* **Fig. CS12.1**)

h: Deck load (kN/m^2) specified in **17.1**

w: Deck load (kN) supported by the tween deck pillar as specified in **11.2**

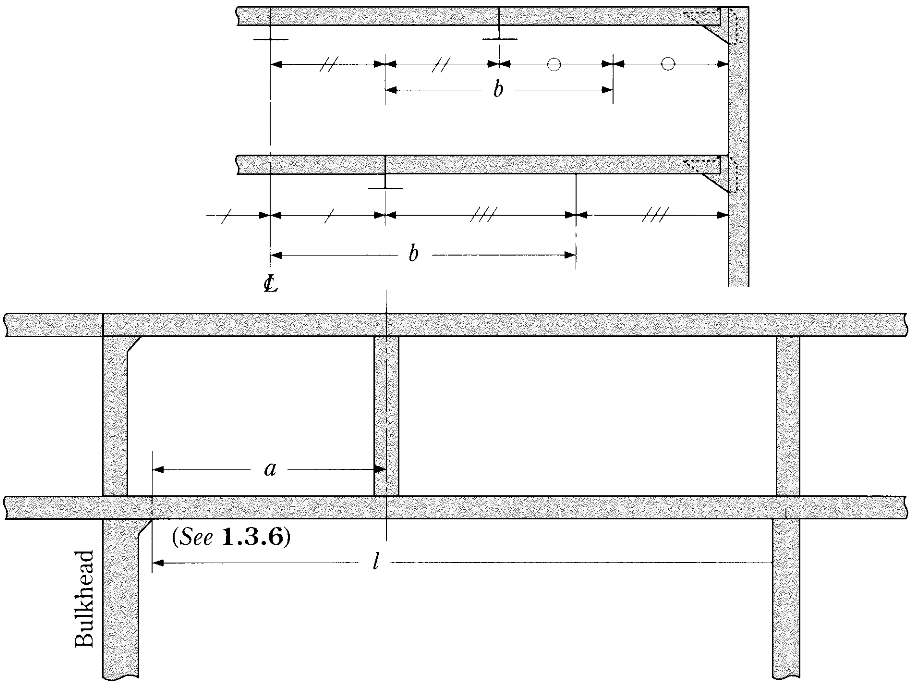
k: As specified in the following **(1)** and **(2)**:

(1) Coefficient obtained from the following formula according to the ratio of the horizontal distance (m) from the pillar or bulkhead supporting the deck girder to the tween deck pillar a and l. (*See* **Fig. CS12.1**)

$$12\frac{a}{l}\left(1-\frac{a}{l}\right)^2$$

(2) Where there is only one tween deck pillar, k is to be obtained by measuring a from the closest pillar or bulkhead. Where there are two or more tween deck pillars, a is to be measured from the same end of l for each tween deck pillar, and sum of kw is to be used for the calculation of the formula. In this case, the greater value of kw is to be used.

Fig. CS12.1 Measurement of l, a and b



2 The section modulus may be gradually reduced for longitudinal deck girders outside the line of openings of the strength deck for the parts forward and afterward of the midship part. However, the section modulus is not to be less than that obtained from the following formula:

$$0.484l(lbh+kw)\ (cm^3)$$

Where:

l, b, h, w and k : As specified in **-1**.

3 The section modulus of longitudinal deck girders for parts other than that stipulated in **-1** and **-2** is not to be less than that obtained from the formula in **-2**.

4 The section modulus of longitudinal deck girders of decks carrying cargoes which can not be treated as evenly distributed loads is to be determined by taking into account the load distribution of each other particular cargo. Where cargo loads can be treated as concentrated loads acting on specific points, the provisions of **-1** to **-3** above may be applied so that such concentrated loads are treated as deck loads supported by the upper tween deck pillars (w).

12.2.2 Moment of Inertia of Girders

It is advised that the moment of inertia of girders is not to be less than that obtained from the following formula:

$$CZl\ (cm^4)$$

Where:

C : Coefficient obtained from the followings:

For deck girders arranged outside the line of deck openings of strength deck of midship part of ship: 1.6

For other deck girders: 4.2

Z : Required section modulus (cm^3) of girders specified in **12.2.1**

l : As specified in **12.2.1-1**

12.2.3 Thickness of Web Plates

1 The thickness of web plates is not to be less than that obtained from the following formula:

$10S_1 + 2.5 \ (mm)$

Where:

S_1: Spacing (m) of web stiffeners or depth of girders, whichever is smaller

2 The thickness of web plates at both end parts for 0.2 l is not to be less than that specified in **-1** and obtained from the following formula, whichever is greater.

$$\frac{4.43}{1000}\frac{bhl}{d_0} + 2.5 \ (mm)$$

Where:

d_0: Depth of girder (m)

b, h and l : As specified in **12.2.1-1**

3 The thickness of web plates provided in the deep tanks is to be 1 mm thicker than that those obtained from the formulae in **-1** and **-2**.

12.3 Transverse Deck Girders

12.3.1 Section Modulus of Girders

1 The section modulus of transverse deck girders is not to be less than that obtained from the following formula:

$0.484l(lbh + kw) \ (cm^3)$

Where:

l: Distance (m) between the centres of pillars or from the centre of the pillar to the inner edge of the beam bracket

b: Distance (m) between the centres of two adjacent girders or from the centre of the girder to the bulkhead

h: Deck load specified in **17.1** (kN/m^2)

w and k : In accordance with **12.2.1-1**.

2 The section modulus of transverse deck girders of decks carrying cargoes which can not be treated as evenly distributed loads is to be determined by taking into account the load distribution of each particular cargo. Where cargo loads can be treated as concentrated loads acting on specific points, the provisions of **-1** above may be applied so that such concentrated loads are treated as deck loads supported by the upper tween deck pillars (w).

12.3.2 Moment of Inertia of Girders

It is advised that the moment of Inertia of girders is not to be less than that obtained from the following formula:

$4.2Zl \ (cm^4)$

Where:

Z : Required section modulus (cm^3) of girders specified in **12.3.1**

l : As specified in **12.3.1**.

12.3.3 Thickness of Web Plates

The thickness of web plates is to be in accordance with the requirements in **12.2.3**.

12.4 Deck Girders in Tanks

12.4.1 Section Modulus of Girders

The section modulus of deck girders in tanks is to be in accordance with the requirements in **12.2.1** or **12.3.1**, and the requirements in **14.2.4-1**.

12.4.2 The Moment of Inertia of Girders

The moment of inertia of girders in tanks is to be in accordance with the requirements in **14.2.4-2**.

12.4.3 Thickness of Web Plates

The thickness of web plates is to be in accordance with the requirements in **12.2.3** or **12.3.3**, and the requirements in **14.2.4-3**.

12.5 Hatch Side Girders

12.5.1 Girders Having Deep Coamings on Decks

Where deep coamings are provided on decks as in the case of hatchway on weather decks, the horizontal coaming stiffener and the coaming up to its stiffener may be included in the calculation of the section modulus, subject to the approval by the Society.

12.5.2 Strength Continuity at Hatchway Corners

At hatchway corners, the face plates of hatch coamings and longitudinal deck girders or their extensions and the face plates on both sides of hatch end girders are to be effectively connected so as to maintain strength continuity.

12.6 Hatch End Beams

12.6.1 Scantlings of Hatch End Beams

The scantlings of hatch end beams are to be in accordance with the requirements in **12.3** and **12.4**.

Chapter 13 WATERTIGHT BULKHEADS

13.1 Arrangement of Watertight Bulkheads

13.1.1 Collision Bulkheads*

1 All ships are to have a collision bulkhead, at a position not less than 0.05 L_f, from the forward terminal of the length for freeboard, but not more than 0.08 L_f or 0.05 L_f + 3.0 (*m*), whichever is greater, unless for special reasons which are approved by the Society. However, where any part of the ship below the waterline at 85% of the least moulded depth extends forward beyond the forward terminal of the length for freeboard, the above-mentioned distance is to be measured from the point that gives the smallest measurement from the following.

(a) The mid-length of such an extension

(b) A distance 0.015 L_f forward from the above-mentioned forward terminal

2 The bulkhead may have steps or recesses within the limits specified in **-1** above.

3 Any access openings, doors, manholes or ducts for ventilation, etc. are not to be cut in to the collision bulkhead below the freeboard deck. Where a collision bulkhead extends up to a deck above the freeboard deck in accordance with the requirements of **13.1.5(2)**, the number of openings in the extension of the collision bulkhead is to be kept to a necessary minimum and all such openings are to be provided with weathertight means of closing.

4 The arrangement of the collision bulkhead in a ship provided with bow doors is to be at the discretion of the Society. However, where a sloping ramp forms a part of the collision bulkhead above the freeboard deck, the part of the ramp which is more than 2.3 *m* above the freeboard deck may extend forward of the limit specified in **-1** above. In this case, the ramp is to be weathertight over its complete length. However, ramps not meeting the above requirement are to be disregarded as an extension of the collision bulkhead.

5 The factor s_i calculated in accordance with **4.2.3** will not be less than 1 at the deepest subdivision draught loading condition, level trim or any forward trim loading conditions, if any part of the ship forward of the collision bulkhead is flooded without vertical limits.

13.1.2 After Peak Bulkheads

1 All ships are to have an after peak bulkhead situated at a suitable position.

2 The stern tube is to be enclosed in a watertight compartment by the after peak bulkhead or other suitable arrangements.

13.1.3 Machinery Space Bulkheads

A watertight bulkhead is to be provided at each end of the machinery space.

13.1.4 Hold Bulkheads

1 Cargo ships, of an ordinary type, which are not less than 67 *metres* in length, are to have hold bulkheads in addition to the bulkheads specified in **13.1.1** to **13.1.3** at reasonable intervals so that the total number of watertight bulkheads may not be less than that given by **Table CS13.1**.

Table CS13.1 Number of Watertight Bulkheads

L (*m*)		Total number of bulkhead
and above	under	
67	87	4
87	90	5

2 Where it is impracticable to adhere to the number of hold bulkheads required above due to the requirements for the ship's trade, an alternative arrangement may be accepted subject to the approval by the Society.

13.1.5 Height of Watertight Bulkheads*

The watertight bulkheads required in **13.1.1** to **13.1.4** are to be extended to the freeboard deck with the following exceptions:

(1) A watertight bulkheads in way of the raised quarter or the sunken forecastle deck to be extended up to the said deck.

(2) Where a forward superstructure having opening without closing appliances leads to a space below the freeboard deck, or a long

forward superstructure is provided, the collision bulkhead is to extend up to the deck next above the freeboard deck and to be made weathertight. However, where all parts of the extension, including any part of the ramp attached to it are located within the limits specified in **13.1.1** and the part of the deck which forms the step is made effectively weathertight, it need not be fitted directly above the collision bulkhead.

(3) The aft peak bulkhead may terminate at a deck below the freeboard deck and above the designed maximum load line, provided that this deck is made watertight to the stern of the ship.

13.1.6 Transverse Strength of Hull

1 Where the watertight bulkheads required in **13.1.1** to **13.1.5** are not extended up to the strength deck, deep webs or partial bulkheads situated immediately or nearly above the main watertight bulkheads are to be provided so as to maintain the transverse strength and stiffness of the hull.

2 Where the length of a hold exceeds 30 *metres*, suitable means are to be provided so as to maintain the transverse strength and stiffness of the hull.

13.2 Construction of Watertight Bulkheads

13.2.1 Thickness of Bulkhead Plates

The thickness of bulkhead plates is not to be less than that obtained from the following formula:

$$3.2S\sqrt{h}+2.5 \quad (mm)$$

Where:

S: Spacing (m) of stiffeners

h: Vertical distance (m) measured from the lower edge of the bulkhead plates to the bulkhead deck at the centre line of ship. It is not to be less than 3.4 *metres*.

13.2.2 Increase in Thickness of Plates of Special Parts

1 The thickness of the lowest strake of bulkhead plating is to be at least 1 *mm* thicker than obtained from the formula in **13.2.1**.

2 The lowest strake of bulkhead plating is to extend at least 610 *mm* above the top of the inner bottom plating in way of double bottom or about 915 *mm* above the top of keel in way of single bottom. Where the double bottom is provided only on one side of the bulkhead, the extension of the lowest strake is to be up to the higher of the two heights given in the preceding sentence.

3 The bulkhead plating in the limber is to be at least 2.5 *mm* thicker than given in **13.2.1**.

4 The bulkhead plating is to be doubled or increased in thickness in way of the stern tube opening or propelling shaft opening, notwithstanding the requirements in **13.2.1**.

13.2.3 Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula :

$$2.8CShl^2 \quad (cm^3)$$

Where:

l: Span (m) measured between the adjacent supports of stiffeners including the length of connection

Where girders are provided, l is the distance from the heel of the end connection to the first girder or the distance between the girders.

S: Spacing (m) of stiffeners

h: Vertical distance (m) measured from the mid-point of l for vertical stiffeners, and from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners, to the top of bulkhead deck at the centre line of the ship.

Where the vertical distance is less than 6.0 *metres*, h is to be taken as 1.2 *metres* greater than 0.8 *times* the vertical distance.

C: Coefficient given in **Table CS13.2**, according to the type of end connection.

Table CS13.2 Value of C

Vertical Stiffener				
Lower end	Upper end			
	Lug-connection of supported by horizontal girders	Connection		End of stiffener unattached
		Type A	Type B	
Lug-connection or supported by horizontal girders	1.00	1.00	1.15	1.35
Bracketed	0.80	0.80	0.90	1.00
Only the web of stiffener attached at end	1.15	1.15	1.35	1.60
End of stiffener unattached	1.35	1.35	1.60	2.00

Horizontal Stiffener		
The other end	One end	
	Lug-connection, bracketed or supported by vertical girders	End of stiffener unattached
Lug-connection, bracketed or supported by vertical girders	1.00	1.35
End of stiffener unattached	1.35	2.00

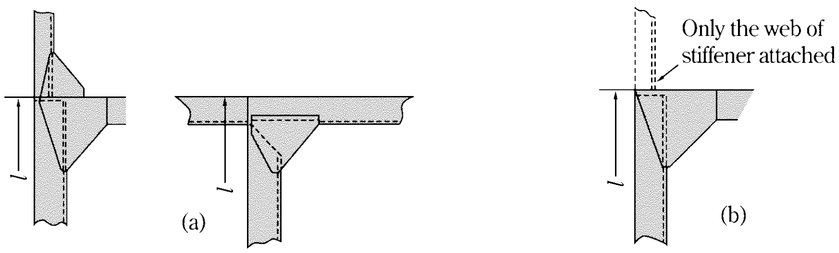
Notes:

1 "Lug-connection" is a connection where both webs and face plates of stiffeners are effectively attached to the bulkhead plating, decks or inner bottoms and which are strengthened by effective supporting members on the opposite side of the plating.

2 "Connection Type A" of vertical stiffeners is a connection by bracket to the longitudinal members or to the adjacent members, in line with the stiffeners, of the same or larger sections. (*See* **Fig. CS13.1 (a)**).

3 "Connection Type B" of vertical stiffeners is a connection by bracket to the transverse members such as beams, or other connections equivalent to the connection mentioned above. (*See* **Fig. CS13.1 (b)**).

Fig. CS13.1 Types of End Connection



13.2.4 Collision Bulkheads

For collision bulkheads, the plate thickness and section modulus of stiffeners are not to be less than that those specified in **13.2.1** and **13.2.3** taking h as 1.25 *times* the specified height.

13.2.5 Girders Supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than that obtained from the following formula :

$4.75Shl^2$ (cm^3)

Where:

S: Breadth (m) of the area supported by the girder

h: Vertical (m) distance measured from the mid-point of l for vertical girders, and from the mid-point of S for horizontal girders, to the top of the bulkhead deck at the centre line of the ship

Where the vertical distance is less than 6.0 *metres*, h is to be taken as 1.2 *metres* greater than 0.8 *times* the vertical distance.

l: Span (m) measured between the adjacent supports of girders

2 The moment inertia of girders is not to be less than that obtained from the following formula. The depth of girders is not to be less than 2.5 *times* the depth of slots for stiffeners.

$10hl^4$ (cm^4)

Where:

h and l : As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$10S_1 + 2.5$ (mm)

Where:

S_1: Spacing (m) of web stiffeners or depth of girders, whichever is the smaller

4 Tripping brackets are to be provided at an interval of about 3 *metres* and where the breadth of face plates exceeds 180 *mm* on either side of the girder, these brackets are to be so arranged as to support the face plates.

13.2.6 Strengthening of Bulkhead Plating, Deck Plating and Other Plating

Plating of bulkheads, decks, inner bottoms, etc. are to be, if necessary, strengthened at the location of the end brackets of stiffeners and the end of girders.

13.2.7 Bulkhead Recesses

1 In way of bulkhead recesses, beams are to be provided at every frame and under the upper bulkhead in accordance with the requirements in **10.3.3** and **13.2.3** taking the beam spacing as the stiffener spacing. Where the lower end of the upper bulkhead is specially strengthened, the beam under the upper bulkhead may be dispensed with.

2 The thickness of deck plating in way of bulkhead recesses is to be at least 1 *mm* greater than given by **13.2.1**, regarding the deck plating as bulkhead plating and the beams as stiffeners. However, the thickness is not to be less than required for deck plating in that location.

3 The thickness of pillars supporting bulkhead recesses are to be determined taking into account the water pressure that might be applied on the upper surface of the recesses, and their end connections are to be sufficiently strong enough to withstand the water pressure which might be applied on the under surface.

13.2.8 Construction of Bulkheads in way of Watertight Doors

Where stiffeners are cut or the spacing of stiffeners is increased in order to provide the watertight door in the bulkhead, the opening is to be suitably framed and strengthened as to maintain the full strength of the bulkhead. The door frames are not to be considered as stiffeners.

13.2.9 Corrugated Bulkhead

1 The plate thickness of corrugated bulkheads is not to be less than that obtained from the following formula:

$3.4CS_1\sqrt{h} + 2.5$ (mm)

Where:

h: As specified in **13.2.1**

S_1: Breadth (m) of face part or web part indicated as *a* or *b*, respectively, in **Fig. CS13.2**

C: Coefficient given below:

Face part: $\dfrac{1.5}{\sqrt{1+\left(\frac{t_w}{t_f}\right)^2}}$

Web part: 1.0

t_f and t_w: Thickness (mm) of plates of face part and web part, respectively

2 The section modulus per half pitch of corrugated bulkheads is not to be less than that obtained from the following formula:

$3.6CShl^2$ (cm^3)

Where:

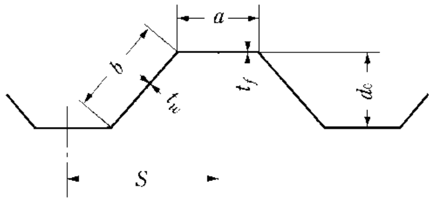
S: Half pitch length (m) of the corrugation (*See* **Fig. CS13.2**)

h: As specified in **13.2.3**

l: Length (m) between the supports, as indicated in **Fig. CS13.3**

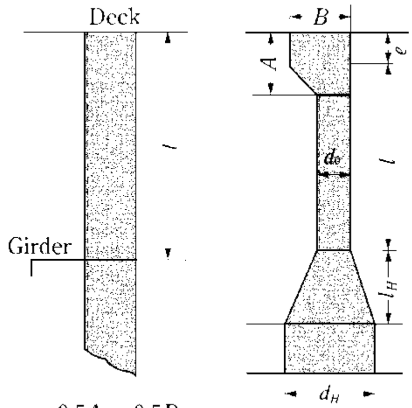
C: Coefficient given in **Table CS13.3**, according to the type of end connection

Fig. CS13.2 Measurement of S



$S_1 = a$ or b.
S = Half pitch length.

Fig. CS13.3 Measurement of l



$e = 0.5A$ or $0.5B$.
whichever is smaller.

Table CS13.3 Values of C (For Corrugated Bulkheads)

The other end of bulkhead		One end of bulkhead		
		Supported by horizontal or vertical girders	Upper end welded directly to deck	Upper end welded to stool efficiently supported by ship structure
(1)	Supported by horizontal or vertical girders or lower end of bulkhead welded directly to decks or inner bottoms	$\frac{4}{2+\frac{Z_1}{Z_0}+\frac{Z_2}{Z_0}}$	$\frac{4}{2.2+\frac{Z_2}{Z_0}}$	$\frac{4}{2.6+\frac{Z_2}{Z_0}}$
(2)	Lower end of bulkhead welded to stool efficiently supported by ship structure	$\frac{4.8(1+\frac{l_H}{l})^2}{2+\frac{Z_1}{Z_0}+\frac{d_H}{d_0}}$	$\frac{4.8(1+\frac{l_H}{l})^2}{2.2+\frac{d_H}{d_0}}$	$\frac{4.8(1+\frac{l_H}{l})^2}{2.6+\frac{d_H}{d_0}}$
		The value of C is not to be less than that obtained from **(1)**		

Notes:

Z_0: Minimum section modulus (cm^3) per half pitch of mid part for $0.6l$ of the corrugated bulkhead

Z_1 and Z_2: Section modulus (cm^3) per half pitch of end part

For vertical corrugation, Z_1 is the section modulus of the upper end part and Z_2 is that of the lower end part. Where the plate thickness is increased in accordance with 13.2.9-5 the section modulus is to be that for the plate thickness reduced by the increment.

l_H: Height (m) of stool measured from inner bottom plating

d_H: Breadth (m) of stool measured on inner bottom plating

d_0: Depth (m) of corrugation

3 Where the end connection of corrugated bulkheads is remarkably effective, the value of C specified in **-2** may be adequately reduced.

4 The thickness of plates at end parts for $0.2l$ in line with l is not to be less than that obtained from the following formulae respectively:

Web part:

$$0.0417\frac{CShl}{d_0}+2.5\ \ (mm)$$

The web thickness is not to be less than that obtained from the following formula:

$$1.74\cdot\sqrt[3]{\frac{CShlb^2}{d_0}}+2.5\ \ (mm)$$

Face part, except the upper end part of vertically corrugated bulkheads:

$$12a+2.5\ \ (mm)$$

Where:

S, h, l and d_0: As specified in **-2**.

a and b: Breadth (m) of face part and web part, respectively

C: Coefficient given in **Table CS13.4**

Where the vertically corrugated bulkheads are constructed with a single span, the value of C may be taken as the value for the uppermost span in the Table.

Table CS13.4 Value of C

Position		Upper end	Lower end
Vertically corrugated bulkhead	Uppermost span	0.4	1.6
	Other spans	0.9	1.1
Both ends of horizontally corrugated bulkhead		1.0	

5 The thickness of the plates specified in **-1** and **-4** is to be in accordance with **13.2.2**.

6 The actual section modulus per half pitch of corrugated bulkheads is to be calculated by the following formula:

$$\frac{at_fd_0}{0.002}+\frac{bt_wd_0}{0.006}\ \ (cm^3)$$

Where:

a and b: Breadth (m) of face part and web part respectively

t_f and t_w: Thickness (mm) of plates of face part and web part respectively

d_0: Depth (m) of corrugation

13.3 Watertight Doors

13.3.1 General

1 All openings in the watertight bulkheads and the part of the deck which forms the step of the bulkheads are to be closed by watertight closing appliances (referred to as "watertight doors" in this chapter) in accordance with the requirements in **13.3.2** to **13.3.5**.

2 Watertight doors as specified in **-1** above are to be normally closed at sea, except where deemed necessary for the ship's operation by the Society. Watertight doors or ramps fitted to internally subdivided cargo spaces are to be permanently closed at sea.

13.3.2 Type of Watertight Doors

1 Watertight doors are to be of a sliding type.

2 Notwithstanding the provisions in **-1** above, watertight doors provided at small access openings, which are approved by the Society, may be of a hinged type or rolling type, except where the doors are required to be capable of being operated remotely by the provisions of **13.3.4-2**.

3 Notwithstanding the provisions in **-1** above, watertight doors or ramps fitted to internally subdivided cargo spaces may be of a type other than the sliding type.

4 Doors which are closed by dropping or by the action of a dropping weight are not permitted.

13.3.3 Strength and Watertightness

1 Water tight doors are to be of ample strength and watertightness for water pressure to a head up to the bulkhead deck and door frames are to be effectively secured to the bulkheads. Where deemed necessary by the Society, watertight doors are to be tested by water pressure before they are fitted.

2 Where watertight doors are provided in cargo spaces, such doors are to be protected by suitable means against damage from items such as cargoes.

13.3.4 Control

1 All watertight doors, except those which are to be permanently closed at sea, are to be capable of being opened and closed by hand locally, from both sides of the doors, with the ship listed 30 degrees to either side.

2 In addition to **-1** above, watertight doors which are used at sea or normally open at sea, are to be capable of being remotely closed by power from the navigation bridge. In this context, "bridge" refers to a place where a watch officer is always present and normally implies the navigation bridge.

3 Watertight doors are not to be able to be opened remotely. In addition, watertight doors complying with the provisions of **13.3.2-3** are not to be remotely controlled.

13.3.5 Indication

Watertight doors, except those permanently closed at sea, are to be provided with position indicators showing whether the doors are open or closed on the bridge and at all operating positions.

13.3.6 Alarms*

1 Failure of the normal power supply of alarms required to be installed by **13.3.6-2** and **13.3.6-3** is to be indicated by an audible and visual alarm. This alarm is to be located on the bridge.

2 Watertight doors which are capable of being remotely closed are to be provided with an audible alarm which will sound at the door position whenever such a door is remotely closed.

3 All watertight doors (including sliding doors) operated by hydraulic door actuators, irrespective of whether their control positions are a central hydraulic unit or local operating position, are to be provided with either a low fluid level alarm, a low gas pressure alarm or some other means as applicable for monitoring the loss of stored energy in the hydraulic accumulators. Such alarms are to be both audible and visible and located on the bridge

13.3.7 Source of Power

1 The remote controls, indications and alarms required in **13.3.4** to **13.3.6** are to be operable in the event of main power failure.

2 Electrical installations for devices specified in **-1** except those of a water-proof type approved by the Society are not to be under the freeboard deck.

3 Cables for devices specified in **-1** are to comply with the requirements of **2.9.11-2, Part H** of the Rules.

13.3.8 Notices

1 Watertight doors which are to be normally closed at sea but not provided with a means of remote closure, are to have notices fixed to both sides of the doors stating "To be kept closed at sea".

2 Watertight doors which are to be permanently closed at sea are to have notices fixed to both sides stating "Not to be opened at sea". Such doors which are accessible during the voyage are to be fitted with a device which prevents unauthorized opening.

13.3.9 Sliding Doors

1 Where a sliding watertight door is operated by rods, the lead of the operating rods is to be as direct as possible and the screw is to work in a nut of brass or other approved materials.

2 The frames of vertically sliding watertight doors are not to have a groove at the bottom in which dirt might lodge and prevent the door from closing.

13.3.10 Hinged Doors and Rolling Doors

1 For hinged and rolling watertight doors, the hinge pins and the wheel axle of these doors are to be of brass or other approved materials.

2 Hinged and rolling watertight doors except those that are to be permanently closed at sea, are to be of single action type which is capable of being closed and secured from both sides of the doors.

13.4 Other Watertight Construction

13.4.1 Maintaining the Watertightness of Trunks

Trunks, etc. required to maintain watertightness are to comply with this chapter.

Chapter 14 DEEP TANKS

14.1 General

14.1.1 Definition

The deep tank is a tank used for the carriage of water, fuel oil and other liquids, forming a part of the hull in holds or tween decks. Deep tanks used for the carriage of oils that need to be especially specified are designated as "deep oil tanks".

14.1.2 Application

1 Peak tank bulkheads and boundary bulkheads of deep tanks (excluding the deep tanks for the carriage of oils having a flashpoint below 60°C) are to be constructed in accordance with the requirements in this Chapter. Where the bulkhead of deep tank partly serves as a watertight bulkhead, the part of the bulkhead is to be in accordance with the requirements in **Chapter 13**.

2 The bulkheads of the deep tanks for carriage of oils having a flashpoint below 60°C are to comply with the requirements in **Chapter 24**, in addition to those in this Chapter.

14.1.3 Divisions in Tanks

1 Deep tanks are to be of a proper size and to be provided with such longitudinal watertight divisions as necessary to meet the requirements for stability in service conditions as well as while the tanks are being filled or discharged.

2 Tanks for fresh water or fuel oil or those which are not intended to be kept entirely filled in service conditions are to have additional divisions or deep wash plates as necessary to minimize the dynamic forces acting one to the structure.

3 Where it is impracticable to comply with the requirements in **-2**, the scantlings required in this Chapter are to be properly increased.

4 Longitudinal watertight divisions which will be subjected to pressure from both sides, in tanks which are to be entirely filled or emptied in service conditions, may be of the scantlings required for ordinary watertight bulkheads as stipulated in **Chapter 13**. In such cases, the tanks are to be provided with fitting such as deep hatches and inspection plugs in order to ensure that the tanks are kept full in service conditions.

14.2 Deep Tank Bulkheads

14.2.1 Application

The construction of bulkheads and decks forming boundaries of deep tanks is to be in accordance with the requirements in **Chapter 13**, unless otherwise specified in this Chapter.

14.2.2 Bulkhead Plates

The thickness of deep tank bulkhead plating is not to be less than that obtained from the following formula:

$$3.6S\sqrt{h} + 3.5 \quad (mm)$$

Where:

S: Spacing of stiffeners (m).

h: Greater of the distances given below:

(1) Vertical distance (m) measured from the lower edge of plate to the mid-point between the top of tanks and the top of overflow pipes

However, for bulkheads of large tanks, additional water pressure is to be appropriately considered.

(2) 0.7 *times* the vertical distance (m) measured from the lower edge of the plate to the point 2.0 *metres* above the top of the overflow pipes

14.2.3 Bulkhead Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$7CShl^2 \quad (cm^3)$$

Where:

S and l: As specified in **13.2.3**

h: Greater of the vertical distances given below, with the lower end being regarded as the mid-point of l for vertical stiffeners and as the mid-point of distance between the adjacent stiffeners for horizontal stiffeners

(1) Vertical distance (m) measured from the lower end to the mid-point between the top of the tanks and the top of the overflow pipes
However, for bulkhead stiffeners of large tanks, additional water pressure is to be appropriately considered.

(2) 0.7 *times* the vertical distance (m) measured from the lower end to the point 2.0 *metres* above the top of overflow pipes

C: Coefficient given in **Table CS14.1**, according to the type of end connections.

Table CS14.1 Value of C

Vertical Stiffener					
The other end of stiffeners		One end of stiffeners			
		Lug-connection or supported by girders	Connection		End of stiffener unattached
			Type A	Type B	
Lug-connection or supported by girders		1.00	0.85	1.30	1.50
Connection	Type A	0.85	0.70	1.15	1.30
	Type B	1.30	1.15	0.85	1.15
End of stiffener unattached		1.50	1.30	1.15	1.50

Notes:

1 "Connection Type A" is a connection by bracket of the stiffener to the double bottoms or to a stiffener of equivalent strength attached to the face plates of adjacent members, or a connection of equivalent strength.(*See* **Fig. CS13.1 (a)**)

2 "Connection Type B" is a connection by bracket of the stiffener to the transverse members such as beams, frames or equivalent thereto.(*See* **Fig. CS13.1 (b)**)

14.2.4 Girders Supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than that obtained from the following formula:

$7.13Shl^2$ (cm^3)

Where:

S: Breadth (m) of the area supported by the girders

h: Vertical distance (m) measured from the mid-point of S for horizontal girders, and from the mid-point of l for vertical girders, to the top of h specified in **14.2.3**

l: Span (m) measured between the adjacent supports of girders

2 The moment of inertia of girders is not to be less than that obtained from the following formula. The depth of girders is not to be less than 2.5 times the depth of slots for stiffeners.

$30hl^4$ (cm^4)

Where:

h and l: As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$10S_1 + 3.5$ (mm)

Where:

S_1: Spacing (m) of web stiffeners or the depth of girders, whichever is smaller

14.2.5 Cross Ties

1 Where efficient cross ties are provided across deep tanks connecting girders on each side of the tanks, the span (l) of girders specified in **14.2.4** may be measured between the end of the girder and the centre line of the cross tie or between the centre lines of adjacent cross ties.

2 The sectional area of cross ties is not to be less than that obtained from the following formula:

$1.3Sb_sh$ (cm^2)

Where:

S and h: As specified in **14.2.4**.

b_s: Breadth of the area supported by the cross ties (m).

3 The ends of cross ties are to be bracketed to girders.

14.2.6 Top and Bottom Construction

The scantlings of the members forming the top or the bottom of deep tanks are to be in accordance with the requirements in this Chapter, where the members are treated as if they were members forming a deep tank bulkhead at that location. The scantlings of the members are not to be less than that required by the other requirements for the construction of the tank top as well as the bottom. For top plating of deep tanks, the thickness of plates is to be at least one *mm* greater than the thickness specified in **14.2.2**.

14.2.7 Scantlings of Members Not in Contact with Sea Water

The thickness of plates of bulkheads and girders which are not in contact with sea water in service conditions may be reduced from the requirements in **14.2.2** and **14.2.4-3** by the values given below:

For plates with only one side in contact with sea water: 0.5 *mm*

For plates with neither side in contact with sea water: 1.0 *mm*

However, bulkhead plates in way of locations such as bilge well are to be regarded as the plates in contact with sea water.

14.2.8 Corrugated Bulkhead

1 The thickness of plates of corrugated bulkheads is not to be less than that obtained from the following formula:

$$3.6CS_1\sqrt{h} + 3.5 \quad (mm)$$

Where:

S_1: As specified in **13.2.9-1**

h: As specified in **14.2.2**

C: Coefficient given below:

For face part: $\dfrac{1.4}{\sqrt{1+\left(\dfrac{t_w}{t_f}\right)^2}}$

For web part: 1.0

t_f and t_w: As specified in **13.2.9-1**

2 The section modulus per half pitch of corrugated bulkheads is not to be less than that obtained from the following formula:

$$7CShl^2 \quad (cm^3)$$

Where:

S: As specified in **13.2.9-2**

h: As specified in **14.2.3**

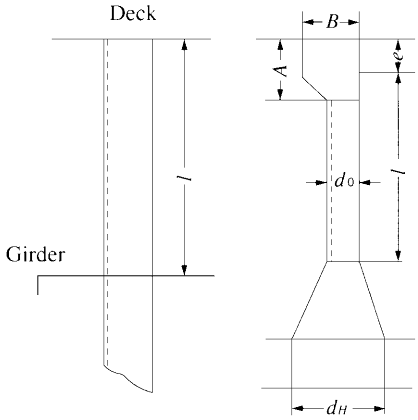
l: Length (m) between the supports, as indicated in **Fig. CS14.1**

C: Coefficient given in **Table CS14.3**, according to the type of end connection

For bulkheads with lower stools of which the width in the longitudinal direction at the lower end, d_H, is less than 2.5 times the web depth of the bulkhead, d_0 (*See* **Fig. CS14.1**), the measurement of l and the values of C are to be at the discretion of the Society.

For vertically corrugated bulkheads, the section modulus per half pitch of the upper part of a corrugated bulkhead which is located above one third of the span measured between the upper deck and the supporting point may not be less than 75% of that obtained by the above formula.

Fig. CS14.1 Measurement of l



$$e = A - \frac{d_0}{2B}A$$

Table CS14.3 Values of C

Column	Lower end	Upper end		
		Supported by Girders	Welded directly to deck	Welded to stool efficiently supported by ship structure
(1)	Supported by girders or welded directly to decks or inner bottoms	1.00	1.50	1.35
(2)	Welded to stool efficiently supported by ship structure	1.50	1.20	1.00

3 The thickness of plates at end parts for 0.2 l in line with l is not to be less than that obtained from the following formulae:

Thickness of web part:

$$0.0417\frac{CShl}{d_0} + 3.5 \ (mm)$$

Not to be less than that obtained from the following formula:

$$1.74 \cdot \sqrt[3]{\frac{CShlb^2}{d_0}} + 3.5 \ (mm)$$

Thickness of the face part except the upper end part of vertically corrugated bulkheads:

$$12a + 3.5 \ (mm)$$

Where:

h: As specified in **14.2.3**

C, S, d_0, a and b: As specified in **13.2.9-4**

l: As specified in **-2**

14.3 Fittings of Deep Tanks

14.3.1 Limbers and Air Holes

Limbers and air holes are to be cut suitably in the structural members to ensure that air or water does not remain stagnated in any part of the tank.

14.3.2 Drainage from Top of Tanks

Efficient arrangements are to be made for draining bilge water from the top of deep tanks.

14.3.3 Inspection Plugs

The inspection plugs provided on deep tank tops as required in **14.1.3** are to be located in readily accessible positions, and the plugs are to be open as far as is practicable when filling the tank with water.

14.3.4 Cofferdams

1 Oiltight cofferdams are to be provided between tanks carrying oils and those carrying fresh water, such as for personnel use or boiler feed water, etc., to prevent the fresh water from being contaminated by the oil.

2 Crew spaces and passenger spaces are not to be directly adjacent to tanks carrying fuel oil. Such compartments are to be separated from the fuel oil tanks by cofferdams which are well ventilated and accessible. Where the top of fuel oil tanks have no opening and is coated with incombustible coverings of not less than 38 *mm* in thickness, the cofferdam between such compartments and the top of the fuel oil tanks may be omitted.

Chapter 15 LONGITUDINAL STRENGTH

15.1 General

15.1.1 Special Cases in Application

Where there are items for which direct application of the requirements in this Chapter is deemed unreasonable, these items are to be in accordance with the discretion of the Society.

15.1.2 Continuity of Strength

Longitudinal members are to be so arranged as to maintain the continuity of strength.

15.2 Bending Strength

15.2.1 Bending Strength at the Midship Part

1 The section modulus of the transverse sections of the hull at the midship part is not to be less than the value of Z_σ obtained from the following formula. However, application of the requirement may be dispensed with to ships not exceeding 60 *metres* in length at the discretion of the Society.

$$Z_\sigma = 5.72(M_s + M_w) \ (cm^3)$$

Where:

M_S: Maximum longitudinal bending moments in still water (*kN-m*) for sagging and hogging, respectively, which are calculated at the transverse section under consideration along the length of the hull for all conceivable loading conditions by a method of calculation deemed appropriate by the Society.

M_w: Wave induced longitudinal bending moment (*kN-m*) at the transverse section under consideration along the length of the hull, which is obtained from the following formulae, corresponding to either the sagging or the hogging moment of M_S:

$0.11C_1C_2L_1^2B(C_b' + 0.7)$ (*kN-m*) for sagging moment of M_S

$0.19C_1C_2L_1^2BC_b'$ (*kN-m*) for hogging moment of M_S

C_1: As given by the following formula: $0.03 L_1 + 5$

L_1: Distance (*m*) measured on the waterline at the scantling draught d_S from the forward side of the stem to the centre of the rudder stock. L_1 is to be not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught d_S. In ships without rudder stocks (e.g. ships fitted with azimuth thrusters), the Rule length L_1 is to be taken equal to 97% of the extreme length on the waterline at the scantling draught d_S.

d_S: Scantling draught (*m*) at which the strength requirements for the scantlings of the ship are met and represents the full load condition; it is to be not less than that corresponding to the assigned freeboard.

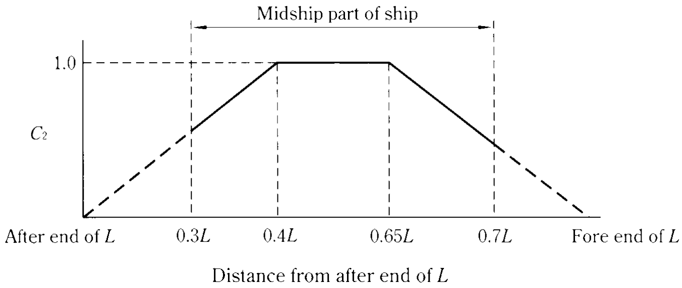
C_b': Volume of displacement corresponding to the scantling draught d_S divided by $L_1B_Sd_S$

However, the value is to be taken as 0.6, where it is less than 0.6.

B_S: Breadth (*m*) measured amidships at the scantling draught d_S.

C_2: Coefficient specified along the length at positions where the transverse section of the hull is under consideration, as given in **Fig. CS15.1**

Fig. CS15.1 Value of Coefficient C_2



2 Notwithstanding the requirements of **-1** above, the section modulus of the transverse section of the hull at the middle point of L is not to be less than the value of W_{min} obtained from the following formula:

$$W_{min} = C_1 L_1^2 B (C_b' + 0.7) \ (cm^3)$$

Where:

C_1, L_1, C_b': As specified in **-1** above

3 Moment of inertia of the transverse section of the hull at the middle point of L is not to be less than the value obtained from the following formula. Note, however, that the calculation method for the moment of inertia of the actual transverse section is to be correspondingly in accordance with the requirements in **15.2.3**.

$$3W_{min} L_1 \ (cm^4)$$

Where:

W_{min}: Section modulus of the transverse section of hull at the middle point of L as specified in **-2** above

L_1 : As specified in **-1** above

4 The scantlings of longitudinal members in way of the midship part are not to be less than the scantlings of longitudinal members at the middle point of L which are determined by the requirement in **-2** and **-3** above, excluding changes in the scantlings due to variations in the sectional form of the transverse section of the hull.

15.2.2 Bending Strength at Sections other than the Midship Part

The bending strength of hull at sections other than the midship part is to be as determined according to the requirements of **17.3**.

15.2.3 Calculation of Section Modulus of Transverse Section of Hull

The calculation of the section modulus of the transverse section of the hull is to be based on the following requirements, as given in **(1)** through **(6)**.

(1) All longitudinal members which are considered effective to longitudinal strength are to be included in the calculation.

(2) Deck openings on the strength deck are to be deducted from the sectional area used in the calculation of the section modulus. However, small openings not exceeding 2.5 *metres* in length and 1.2 *metres* in breadth need not be deducted, provided that the sum of their breadths in any single transverse section is not more than $0.06\left(B - \sum b\right)$. $\sum b$ is the sum of the openings exceeding 1.2 *metres* in breadth or 2.5 *metres* in length.

(3) Notwithstanding the requirement in **(2)**, small openings on the strength deck need not be deducted, provided that the sum of their breadths in one single transverse section does not reduce the section modulus at the strength deck or the ship bottom by more than 3%.

(4) Deck openings specified in **(2)** and **(3)** include shadow areas obtained by drawing two tangential lines with an opening angle of 30 degrees having their apex on the line drawn through the centre of the small openings along the length of the ship.

(5) The section modulus at the strength deck is to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the following distance **(a)** or **(b)**, whichever is greater.

(a) Vertical distance (m) from the neutral axis to the top of the strength deck beam and the side of the ship

(b) Distance (m) obtained from the following formula:

$$Y(0.9 + 0.2\frac{X}{B})$$

Where:

X : Horizontal distance (m) from the top of continuous strength member to the centre line of the ship

Y : Vertical distance (m) from the neutral axis to the top of the continuous strength member

In this case, X and Y are to be measured at the point which gives the largest value, for the above formula.

(6) The section modulus at the ship bottom is to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the vertical distance from the neutral axis to the top of the keel.

15.3 Buckling Strength

15.3.1 Compressive Buckling Strength

Parts, such as the strength deck plating and bottom shell plating etc., placed under large compressive stresses due to longitudinal bending are to be adequate enough to withstand any compressive buckling.

Chapter 16 PLATE KEELS AND SHELL PLATING

16.1 General

16.1.1 Consideration for Corrosion

The thickness of shell plating at such parts that the corrosion is considered excessive due to the location and/or special service condition of the ship is to be properly increased over that required in this Chapter.

16.1.2 Special Consideration for Contact with Wharf

Where the shell plating is prone to denting due to continual contact with the wharf, special consideration is to be given to the thickness of the shell plating.

16.1.3 Moving Parts Penetrating the Shell Plating

Moving parts penetrating the shell plating below the deepest subdivision draught specified in **4.1.2(3)**, are to be fitted with a watertight sealing arrangement acceptable to the Society. The inboard gland is to be located within a watertight space of such volume that, if flooded, the freeboard deck is not to be submerged. The Society may require that if such a compartment is flooded, essential or emergency power and lighting, internal communication, signals or other emergency devices remain available in other parts of the ship.

16.2 Plate Keels

16.2.1 Breadth and Thickness of Plate Keels

1 The breadth of the plate keel over the whole length of the ship is not to be less than that obtained from the following formula:

$4.5L + 775$ (mm)

2 The thickness of the plate keel over the whole length of the ship is not to be less than the thickness of the bottom shell obtained from the requirement in **16.3.4** plus 1.5 *mm*. However, this thickness is not to be less than that of the adjacent bottom shell plating.

16.3 Shell Plating for Midship Part of Ship

16.3.1 Minimum Thickness

The minimum thickness of shell plating below the strength deck for the midship part of ship is not to be less than that obtained from the following formula:

$0.044L + 5.6$ (mm)

16.3.2 Thickness of Side Shell Plating

The thickness of side shell plating other than the sheer strake at the strength deck for the midship part of ship is not to be less than that obtained from the following formula:

$4.1S\sqrt{d + 0.04L} + 2.5$ (mm)

Where:

S : Spacing (m) of longitudinal or transverse frames

16.3.3 Sheer Strakes

The thickness of sheer strakes at the strength deck is not to be less than 0.75 times that of the stringer plate of the strength deck. However, the thickness is not to be less than that of the adjacent side shell plating.

16.3.4 Thickness of Bottom Shell Plating

The thickness of bottom shell plating (including bilge strake and excluding keel plate) for the midship part of ship is to be as required in the following **(1)** and **(2)**.

(1) In ships with transverse framing, the thickness is not to be less than that obtained from the following formula:

$4.7S\sqrt{d + 0.035L} + 2.5$ (mm)

Where:

S : Spacing (m) of transverse frames

(2) In ships with longitudinal framing, the thickness is not to be less than that obtained from the following formula.

$4.0S\sqrt{d+0.035L}+2.5 \ (mm)$

Where:

S : Spacing (m) of longitudinal frames

16.4 Shell Plating for End Parts

16.4.1 Shell Plating for End Parts*

Beyond the midship part, the thickness of shell plating below the strength deck may be gradually reduced, but at the end parts the thickness is not to be less than that obtained from the following formula. However, for the parts specified in **16.4.2** to **16.4.5**, the thickness is not to be less than that required in the respective provisions.

$5.6+0.044L \ (mm)$

16.4.2 Shell Plating for 0.3 *L* from the Fore End

The thickness of shell plating for 0.3 L from the fore end is not to be less than that obtained from the following formula:

$1.34S\sqrt{L}+2.5 \ (mm)$

Where:

S : Spacing (m) of longitudinal or transverse frames

16.4.3 Shell Plating for 0.3 *L* from the After End

The thickness of shell plating for 0.3 L from the after end is not to be less than that obtained from the following formula. In ships with machinery aft or in ships with powerful engines, the thickness is to be properly increased:

$1.20S\sqrt{L}+2.5 \ (mm)$

Where:

S : Spacing (m) of longitudinal or transverse frames

16.4.4 Shell Plating of Bottom Forward

The thickness of shell plating at the strengthened bottom forward specified in **6.9.2** is to be as required in the following **(1)**, **(2)** and **(3)**. Where the ship has an unusually small draught at the ballast condition and has especially high speed for the ship's length, special consideration is to be paid to the thickness of shell plating.

(1) In ships having a bow draught of not more than 0.025 L at the ballast condition, the thickness of shell plating at the strengthened bottom forward is not to be less than that obtained from the following formula:

$CS\sqrt{P}+2.5 \ (mm)$

Where:

C : Coefficient given in **Table CS16.1**

For intermediate values of α, C is to be obtained by linear interpolation.

S :Spacing (m) of frames, girders or longitudinal shell stiffeners, whichever is the smallest

α :Value (m) of the spacing of frames, girders or longitudinal shell stiffeners, whichever is the greatest divided by S

P :Slamming impact pressure (kPa) specified in **6.9.4**.

(2) In ships having a bow draught of not less than 0.037 L at the ballast condition, the thickness of shell plating at the strengthened bottom forward may be of thickness specified in **16.4.1** and **16.4.2**.

(3) In ships having an intermediate value of the bow draught specified in **(1)** and **(2)**, the thickness is to be obtained by linear interpolation from the requirements in **(1)** and **(2)**.

Table CS16.1 Value of C

α	1.0	1.2	1.4	1.6	1.8	2.0 and above
C	1.04	1.17	1.24	1.29	1.32	1.33

16.4.5 Shell Plating adjacent to Stern Frames or in way of Spectacle Bossing

The thickness of shell plating adjacent to the stern frame or in way of spectacle bossing is not to be less than that obtained from the following formula:

$4.5 + 0.09L \ (mm)$

16.5 Side Plating in way of Superstructure

16.5.1 Side Plating in way of Superstructure Deck Designed as a Strength Deck

Where the superstructure deck is designed as a strength deck, the thickness of the superstructure side plating is to be as specified in **16.3.1**, **16.3.2** and **16.4.1** to **16.4.3**. However, the superstructure side plating at end parts may be of thickness specified in **16.5.2**.

16.5.2 Side Plating in way of Superstructure Deck Not Designed as a Strength Deck

Where the superstructure deck is not designed as a strength deck, the thickness of the superstructure side plating is not to be less than obtained from the following formula, but it is not to be less than 5.5 mm.

For 0.25 L abaft the fore end

$1.15S\sqrt{L} + 2.0 \ (mm)$

Elsewhere

$0.94S\sqrt{L} + 2.0 \ (mm)$

Where:

S : Spacing (m) of longitudinal or transverse frames at the position

16.5.3 Compensation at Ends of Superstructure

Side plating at the ends of superstructure is to be suitably constructed to maintain the continuity of strength.

16.6 Local Compensation of Shell Plating

16.6.1 Openings in Shell

All openings in the shell plating are to have their corners well rounded and to be compensated as necessary.

16.6.2 Recesses

Where the recesses are provided in the shell plating for suction or discharge, the thickness of the recesses is not to be less than obtained from the following formula and to be suitably stiffened so as to provide sufficient rigidity as necessary.

$5.0 + 0.07L \ (mm)$

16.6.3 Shell Plating at and Below Hawse Pipes

The shell plating fitted with hawse pipes and the plating below them is to be increased in thickness or to be doubled, and to be constructed so that their longitudinal seams are not damages by anchors or anchor cables.

Chapter 17 DECKS

17.1 Value of Deck Load *h*

17.1.1 Value of *h*

1 Deck load h (kN/m^2) for decks intended to carry ordinary cargoes or stores is to be in accordance with the following **(1)** through **(3)**.

(1) The standard value (kN/m^2) for h is given by taking 7 times the tween deck height (m) at side of the space or the height (m) from the deck concerned to the upper edge of the hatch coaming of the deck above as the height of the cargo and multiplying it by 7. However, h may be specified as the maximum design cargo weight per unit area of deck (kN/m^2). In this case, the value of h is to be determined by considering the height of the loaded cargo.

(2) Where timber and/or other cargoes are intended to be carried on the weather deck, h is to be the maximum design cargo weight per unit area of deck (kN/m^2), or the value specified in **-2**, whichever is greater.

(3) Where cargoes are suspended from the deck beams or deck machinery is installed, h is to be suitably increased.

2 Deck load h (kN/m^2) for the weather deck is to be as specified in the following **(1)** to **(4)**.

(1) For the freeboard decks, superstructure deck and top of deckhouses on the freeboard deck, h is not to be less than that obtained from the following formula:

$a(0.067bL - y)$ (kN/m^2)

Where:

a and b : As given by **Table CS17.1** according to the position of decks.

However, where C_b is less than 0.7, value of b may be suitably modified.

y: Vertical distance from the designed maximum load line to the weather deck at side (m), and y is to be measured at fore end for deck forward of 0.15 L abaft the fore end ; at 0.15 L abaft the fore end for deck between 0.3 L and 0.15 L abaft the fore end ; at midship for deck between 0.3 L abaft the fore end and 0.2 L afore that aft end ; and at aft end for deck afterward of 0.2 L afore the aft end. (*See* **Fig. CS17.1**)

(2) h for the deck given in Column II in **Table CS17.1** does not need to exceed that in Column I.

(3) Notwithstanding the provision in **(1)** and **(2)**, h is not to be less than obtained from the formulae given by **Table CS17.2**. However, where the h value calculated from the formula in **Table CS17.2** is less than 12.8, the h value is to be taken as 12.8.

(4) Value of h may be suitably modified where the ship has an unusually large freeboard.

Table CS17.1 Values of a and b

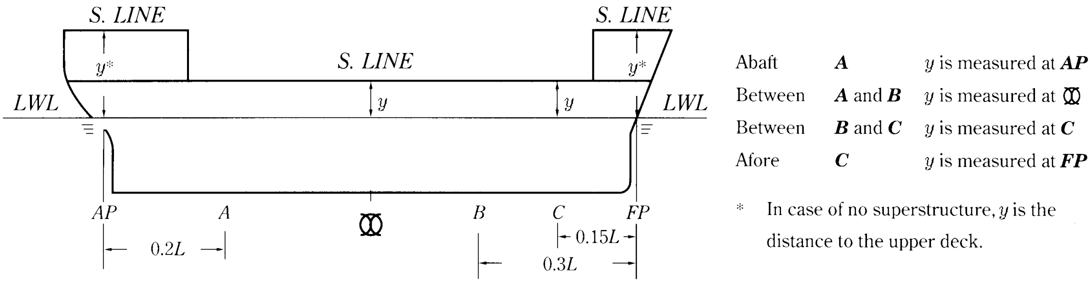
Column	Position of Deck	a				b
		Deck plating	Beams	Pillars	Deck girders	
I	Forward of 0.15 L abaft the fore end	14.7	9.80	4.90	7.35	1.42
II	Between 0.15 L and 0.3 L abaft the fore end	11.8	7.85	3.90	5.90	1.20
III	Between 0.3 L abaft the fore end and 0.2 L afore the aft end	6.90	4.60	2.25	2.25[1] 3.45[2]	1.00
IV	Afterward of 0.2 L afore the aft end	9.80	6.60	3.25	4.90	1.15

Notes:

1 For longitudinal deck girders outside the line of hatchway openings of the strength deck for the midship part

2 For deck girders other than 1

Fig. CS17.1 Position of Measuring y



3 On the first and second tiers above the freeboard deck, h is to be 12.8 for enclosures of superstructure decks and of top of deckhouses in accommodation or navigation spaces.

Table CS17.2 Minimum Value of h

<table>
<tr><th rowspan="2">Column</th><th rowspan="2">Position of deck</th><th rowspan="2">h</th><th colspan="3">C</th></tr>
<tr><th>Beams</th><th>Pillars, Longitudinal and transverse deck girders</th><th>Deck plating</th></tr>
<tr><td>I and II</td><td>Forward of 0.3 L abaft the fore end</td><td rowspan="2">$C\sqrt{L}+50$</td><td>2.85</td><td>1.37</td><td>4.20</td></tr>
<tr><td>III</td><td>Between 0.3 L abaft the fore end and 0.2 L afore the aft end</td><td>1.37</td><td>1.18</td><td>2.05</td></tr>
<tr><td>IV</td><td>Afterward of 0.2 L afore the aft end</td><td rowspan="2">$C\sqrt{L}$</td><td>1.95</td><td>1.47</td><td>2.95</td></tr>
<tr><td colspan="2">Second tier superstructure deck above the freeboard deck</td><td>1.28</td><td>0.69</td><td>1.95</td></tr>
</table>

17.2 General

17.2.1 Steel Deck plating

Decks are to be plated from side to side of the ship except where there are specialized deck openings. However, decks may be of only stringer plates and tie plates, subject to the approval by the Society.

17.2.2 Watertightness of Decks

1 Weather decks, except where hatchway and other openings specified in **Chapter 20** are provided, are to be made watertight.

2 Special consideration is to be given to maintaining watertightness where the decks are required to be watertight in compliance with the requirements of **Chapter 4**.

17.2.3 Continuity of Steps of Decks

Where the strength deck or effective decks (the decks below the strength deck which are considered as strength members in the longitudinal strength of the hull) change in level, special care to preserve the continuity of strength is to be taken. The change in height is to be accomplished by gradual sloping, or by extending each of the structural members which form the decks and tying them effectively together by diaphragms, girders, brackets, etc.

17.2.4 Compensation for Openings

1 Hatchways or other openings on strength or effective decks are to have well rounded corners, and compensation is to be suitably provided as necessary.

2 Where attachments such as slant plates or protective means are provided on hatch corners of cargo hatchways, such attachments are not to be directly welded onto strength decks.

17.2.5 Rounded Gunwales

Rounded gunwales, where adopted, are to have a sufficient radius for the thickness of the plates.

17.3 Effective Sectional Area of Strength Deck

17.3.1 Definition

The effective sectional area of the strength deck is the sectional area, on each side of the ship, of steel plating, longitudinal beams, girders, etc. extending for 0.5 L amidships.

17.3.2 Effective Sectional Area of Strength Deck

1 The effective sectional area for the midship part for which the modulus of athwartship section of the hull is specified in **Chapter 15** is to be so determined as to comply with the requirements in **Chapter 15**.

2 Beyond the midship part, the effective sectional area of strength deck may be gradually reduced less than the value at the end of the midship part. However, the values at the position 0.15 L from the after and fore end of L, respectively, are not to be less than 0.4 times the value at the middle point of L for ships with machinery amidships, or 0.5 times for ships with machinery aft.

3 Where the section modulus of the athwartship section other than the midship part is greater than the value approved by the Society, the requirements specified in the provisory clause in **-2** may not be necessarily applied.

17.3.3 Strength Deck beyond 0.15 *L* from Both Ends

Beyond 0.15 L from each end, the effective sectional area and the thickness of the strength deck plating may be gradually reduced avoiding abrupt changes.

17.3.4 Effective Sectional Area of Strength Deck within Long Poop

Notwithstanding the requirements in **17.3.2**, the effective sectional area of the strength deck within long poop may be properly modified.

17.3.5 Deck within Superstructure where Superstructure Deck is Designed as Strength Deck

Where the superstructure deck is designed as the strength deck, the strength deck plating clear of the superstructure is to extend into the superstructure for about 0.05 L without reducing the effective sectional area, and may be gradually reduced within.

17.4 Deck Plating

17.4.1 Thickness of Deck Plating

1 The thickness of deck plating is not to be less than that obtained from the formula in **(1)** or **(2)**. However, within enclosed spaces such as superstructures and deckhouses, the thickness may be reduced by 1 *mm*.

(1) The thickness of strength deck plating:

(a) Outside the line of openings for the midship part with longitudinal beams

$$1.47S\sqrt{h}+2.5 \ (mm)$$

Where:

S: Spacing (m) of longitudinal beams

h: Deck load (kN/m^2) specified in **17.1**

(b) Outside the line of openings for the midship part with transverse beams

$$1.63S\sqrt{h}+2.5 \ (mm)$$

Where:

S: Spacing (m) of transverse beams

h: Deck load (kN/m^2) specified in **17.1**

(c) Elsewhere

$$1.25S\sqrt{h}+2.5 \ (mm)$$

Where:

S: Spacing m) of longitudinal or transverse beams

h: Deck load (kN/m^2) specified in **17.1**

(2) The thickness of deck plating other than the strength deck is to be specified in the following:

$$1.25S\sqrt{h}+2.5 \ (mm)$$

Where:

S and h: As specified in **(1)(c)**

2 Where decks inside the line of openings are longitudinally framed, adequate care is to be taken to prevent buckling of the deck plating.

17.4.2 Deck Plating Forming the Tops of Tanks

The thickness of deck plating forming the top of tanks is not to be less than that required in **14.2.2** for deep tank bulkhead plating, taking the beam spacing as the stiffener spacing.

17.4.3 Deck Plating Forming Bulkhead Recesses

The thickness of deck plating forming the top of shaft tunnels, thrust recesses or bulkhead recesses is not to be less than that required in **13.2.7-2.**

17.4.4 Deck Plating under Boilers or Refrigerated Cargoes

1 The thickness of deck plating under boilers is to be increased by 3 *mm* above the specified thickness.

2 The thickness of deck plating under refrigerating chamber is to be increased by one *mm* above the specified thickness. Where special means for the protection against the corrosion of the deck is provided, the thickness need not be increased.

17.4.5 Thickness of Deck Plating Loaded with Wheeled Vehicles

The thickness of deck plating loaded with wheeled vehicles is to be determined by considering the concentrated loads from the wheeled vehicles.

17.4.6 Thickness of Decks Supporting Unusual Cargoes

The thickness of plates of decks carrying cargo loads which can not be treated as evenly distributed loads is to be determined by taking into account the load distribution of each particular cargo.

Chapter 18 SUPERSTRUCTURES AND DECKHOUSES

18.1 General

18.1.1 Application

1 Ships are to be provided with forecastles. However, it may be omitted where the bow freeboard is deemed sufficient by the Society.

2 The construction and scantlings of superstructures and deckhouses are to be in accordance with the relevant Chapters in addition to this Chapter.

3 The requirements in this Chapter are prescribed for the superstructures and deckhouses up to the third tier above the freeboard deck. As for the superstructures and deckhouses above the third tier, the construction and scantlings thereof are to be as deemed appropriate by the Society.

4 As for the superstructures and deckhouses in ships with an especially large freeboard, the construction of bulkhead may be suitably modified subject to the approval by the Society.

18.2 Construction and Scantlings

18.2.1 Head of Water *h*

1 The head of water for the calculation of the scantlings of superstructure end bulkheads and boundary walls of deckhouses is not to be less than that obtained from the following formula:

$$ac\ (bf - y)\ (m)$$

Where:

a: As given by the following formulae:

Exposed front bulkhead and wall of the first tier:

$$2.0 + \frac{L_1}{120}$$

Exposed front bulkhead and wall of the second tier:

$$1.0 + \frac{L_1}{120}$$

Exposed front bulkhead and wall of the third tier, and side walls and protected end bulkheads and front walls:

$$0.5 + \frac{L_1}{150}$$

Aft bulkheads and walls located abaft the midship:

$$0.7 + \frac{L_1}{1000} - 0.8\frac{x}{L_1}$$

Aft bulkheads and walls located afore the midship:

$$0.5 + \frac{L_1}{1000} - 0.4\frac{x}{L_1}$$

b: As given by the following formulae:

Where $\frac{x}{L_1}$ is less than 0.45:

$$1.0 + \left(\frac{0.45 - \frac{x}{L_1}}{C_{b1} + 0.2}\right)^2$$

Where $\frac{x}{L_1}$ is 0.45 and over:

$$1.0+1.5\left(\frac{\frac{x}{L_1}-0.45}{C_{b1}+0.2}\right)^2$$

x: Distance (m) from the bulkhead or end wall to the after perpendicular, or distance from the mid-point of the side wall to the after perpendicular

However, where the length of the side wall exceeds $0.15L_1$, the side wall is to be equally subdivided into span not exceeding $0.15L_1$ and the distance from the mid-point of the subdivisions to the after perpendicular is to be taken.

C_{b1}: Block coefficient

However, where C_b is 0.6 or under, 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. In calculating b for the aft wall located afore the midship, C_{b1} is to be taken as 0.8.

c: Coefficient as given by the following formulae:

For end bulkheads of superstructures: 1.0

For boundary walls of deckhouses: $0.3+0.7\frac{b'}{B'}$

However, where b'/B' is less than 0.25, b'/B' is to be taken as 0.25.

b': Breadth (m) of deckhouse at the position under consideration.

B': Breadth (m) of ship on the exposed deck at the position under consideration.

y: Vertical distance (m) from the designed maximum load line to the mid-point of the span of stiffeners when determining the scantlings of stiffeners; and to the mid-point of plating when determining the thickness of bulkhead or boundary wall plating.

f: Determined as follows:

$$\frac{L_1}{10}e^{\frac{-L_1}{300}}-\left[1-\left(\frac{L_1}{150}\right)^2\right]$$

L_1: Distance (m) measured on the waterline at the scantling draught d_S from the forward side of the stem to the centre of the rudder stock. L_1 is to be not less than 96 % need not exceed 97% of the extreme length on the waterline at the scantling draught d_S. In ships without rudder stocks (e.g. ships fitted with azimuth thrusters), the Rule length L_1 is to be taken equal to 97 % of the extreme length on the waterline at the scantling draught d_S.

d_S: Scantling draught (m) at which the strength requirements for the scantlings of the ship are met and represents the full load condition. d_S is to be not less than that corresponding to the assigned freeboard.

2 The head of water for the calculation of the scantlings of superstructure end bulkheads and boundary walls of deckhouses is not to be less than that obtained from the formulae in **Table CS18.1** irrespective of the provision in **-1**.

Table CS18.1

	Exposed front bulkhead and wall of the first tier	Others
L_1 is 50 *metres* and under	3.0 (m)	1.5 (m)
L_1 exceeds 50 *metres*	$2.5+\frac{L_1}{100}$ (m)	$1.25+\frac{L_1}{200}$ (m)

18.2.2 Thickness of Bulkhead and Wall Plating

1 The thickness of superstructure end bulkhead plating and boundary wall plating is not to be less than that obtained from the following formula:

$3S\sqrt{h}$ (mm)

Where:

h: Head of water (m) specified in **18.2.1**

S: Spacing of stiffeners (m)

2 The thickness of bulkhead and wall plating is not to be less than that obtained from the following formulae, irrespective of the provisions in **-1**:

(1) In the case of $L_1 \geq 65$ m

Bulkhead plating of the first tier:

$$5.0 + \frac{L_1}{100} \ (mm)$$

Plating of other bulkheads, but not less than 5.0 *mm*:

$$4.0 + \frac{L_1}{100} \ (mm)$$

(2) In the case of $L_1 < 65$ *m*

The lowest unprotected front: 5.0 (*mm*)

All other cases: 4.0 (*mm*)

18.2.3 Stiffeners

1 The section modulus of stiffeners on superstructure end bulkheads and deckhouse boundary walls is not to be less than that obtained from the following formula:

$$3.5Shl^2 \ (cm^3)$$

Where:

S and h:As specified in **18.2.2**

l : Tween deck height (*m*)

However, where l is less than 2 *metres*, l is to be taken as 2 *metres*.

2 Both ends of stiffeners on the exposed bulkheads of superstructures and boundary walls of deckhouses are to be connected to the deck by welding except where otherwise approved by the Society.

18.3 Closing Means for Access Openings in Superstructure End Bulkheads and Deckhouses Protecting Companion

18.3.1 Closing Means for Access Openings

1 The doors to be provided on the access openings in the end bulkheads of enclosed superstructures and deckhouses protecting companion ways giving access to the spaces under the freeboard deck or the spaces in the enclosed superstructures are to be in accordance with the requirements in **(1)** through **(5)**:

(1) The doors are to be made of steel or other equivalent materials and to be permanently and rigidly fitted to the bulkheads.

(2) The doors are to be rigidly constructed, to be of equivalent strength to that of intact bulkhead and to be weathertight when closed.

(3) The means for securing weathertightness are to consist of gaskets and clamping devices or other equivalent devices and to be permanently fitted to the bulkhead or the door itself.

(4) The doors are to be operated from both sides of the bulkheads.

(5) Hinged doors are, as a rule, to open outward.

2

(1) The height of sills of access openings specified in **-1** is not to be less than 380 *mm* above the upper surface of the deck. For sills protecting access openings to spaces below the freeboard deck, the height is to comply with the provisions of **19.4.2**. However, higher sills may be required when deemed necessary by the Society.

(2) In principle, portable sills are not permitted.

3 Openings in the top of a deckhouse on a raised quarterdeck or superstructure of less than standard height, having a height equal to or greater than the standard quarterdeck height, are to be provided with an acceptable means of closing but need not be protected by an efficient deckhouse or companionway, provided that the height of the deckhouse is at least the standard height of a superstructure. Openings in the top of the deckhouse which is less than a standard superstructure height may be treated in a similar manner.

18.4 Additional Requirements for Bulk Carriers, Ore Carriers and Combination Carriers, etc.

Bulk carriers defined in **1.3.1(13)** of **Part B** and self-unloading ships defined in **1.3.1(19)** of **Part B** are to be provided with forecastles in accordance with the following requirements. However, the forecastle deck arrangements of ships for which the application of this requirement is, for some reason, difficult are to be at the direction of the Society.

(1) The forecastle is to be an enclosed superstructure.

(2) The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold. (See **Fig. CS18.1**)

(3) The forecastle height H_F above the main deck is to be not less than the value given in the following **(a)** or **(b),** whichever is greater:

(a) $H_C + 0.5$ (m), where H_C is the height of the forward transverse hatch coaming of the foremost cargo hold.

(b) The standard height of superstructure as given in **Table CS18.2**. Intermediate values of L_f are to be obtained by linear interpolation.

(4) With respect to the design loads for the hatch covers and forward transverse hatch coamings of foremost cargo holds, to reduce the load on the forward transverse hatch coaming of the foremost cargo hold and/or the pressure applying abaft on the hatch cover of the foremost cargo hold, the horizontal distance l_F (m) from the hatch coaming to all points of the aft edge of the forecastle deck is to satisfy the following formula:

$$l_F \leq 5\sqrt{H_F - H_C}$$

H_F and H_C: As specified in **(3)**

(5) 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 aft edge at the centre line is forward of the aft edge of the forecastle deck at the horizontal distance l_w (m) satisfying the following formula:

$$l_w \geq H_B/\tan 20°$$

H_B: Height of the breakwater above the forecastle.

Fig. CS18.1

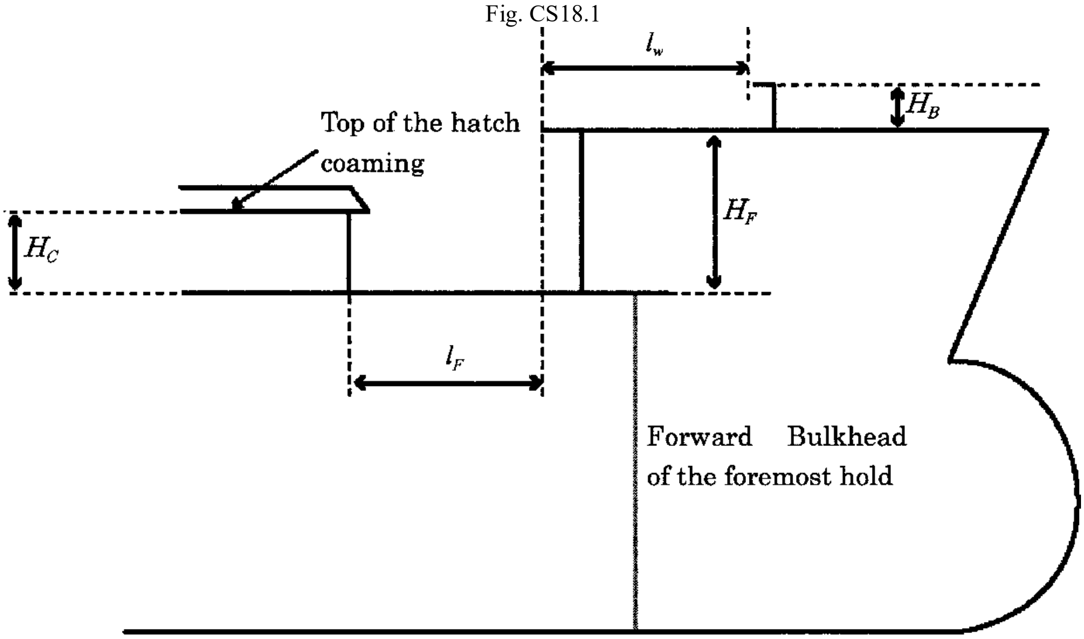


Table CS18.2 Standard Height of Superstructure

Length of ship for freeboard (L_f)	Standard Height of Superstructure (m)
75 m or less	1.80
125 m or more	2.30

Chapter 19 HATCHWAYS, MACHINERY SPACE OPENINGS AND OTHER DECK OPENINGS

19.1 General

19.1.1 Relaxation from the Requirements

Relaxation from the requirements in this Chapter will be specially considered where the ship has an unusually large freeboard.

19.1.2 Position of Exposed Deck Openings

For the purpose of this Chapter, two positions of exposed deck openings are defined as follows:

Position I : Upon exposed freeboard and raised quarter decks and exposed superstructure decks situated forward of the point located 0.25 L_f abaft the for end of L_f.

Position II : Upon exposed superstructure decks situated abaft of the point located 0.25 L_f abaft the fore end of L_f and located at least one standard height of superstructure above the freeboard deck, or

Upon exposed superstructure decks situated forward of the point located 0.25 L_f abaft the fore end of L_f and located at least two standard heights of superstructure above the freeboard deck.

19.1.3 Definitions

The terms used in **19.2** are defined as follows.

(1) "Type 1 ship" means any ship other than "Type 2 ship".

(2) "Type 2 ship" means ore carriers and combination carriers designed to carry either oil or solid cargoes in bulk(e.g. ore/oil carriers) defined in **1.3.1(13)**, **Part B** (excluding those affixed with the notation "*CSR*"), and self-unloading ships defined in **1.3.1(19)**, **Part B**.

19.2 Hatchways

19.2.1 Application

1 The construction and the means for closing of cargo and other hatchways on exposed decks are to comply with the requirements in **19.2**.

2 When the loading condition or the type of construction differs from that specified in this section, the calculation method used is to be as deemed appropriate by the Society.

3 Hatch covers and hatch coamings on non-exposed decks of ships and those of fishing vessels are to be as deemed appropriate by the Society.

19.2.2 General Requirement

1 Primary supporting members and stiffeners of hatch covers are to be continuous over the breadth and length of hatch covers. When this is impractical, appropriate arrangements are to be adopted to ensure sufficient load carrying capacity and sniped end connections are not to be allowed.

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

3 Stiffeners of hatch coamings are to be continuous as far as practical over the breadth and length of said hatch coamings.

19.2.3 Net Scantling Approach

1 Unless otherwise specified, the structural scantlings specified in this section are to be net scantlings which do not include any corrosion additions.

2 "Net scantlings" are the scantlings necessary to obtain the minimum net scantlings required by **19.2.5** and **19.2.9**.

3 Required gross scantlings are not to be less than the scantlings obtained from adding the corrosion addition t_c specified in **-4** below to the net scantlings obtained from the requirements in this section.

4 The corrosion addition t_c is to be taken as specified in **Table CS19.1** according to ship type, the type of structure and structural members of steel hatchway covers, steel pontoon covers and steel weathertight covers (hereinafter referred to as "steel hatch covers").

However, the corrosion additions for structural members that make up hatchway coamings are to be as deemed appropriate by the Society when their t_c values are not specified in **Table CS19.1.**

5 Strength calculations using FEM are to be performed with net scantlings.

Table CS19.1 Corrosion Additions t_c

Type	Ship type	Framing system		t_c (mm)
Type 1 ship	Ships other than the below	Single skin hatch covers		2.0
		Double skin hatch covers	Top, side and bottom plating	1.5
			Internal structural members	1.0
		Hatch coamings, hatch coaming stays and stiffeners		1.5
	Container carrier Car carrier	Hatch covers (in general)		1.0
		Hatch coamings		1.5
Type 2 ship	Ore carrier Combination carriers which are designed to carry either oil or solid cargoes in bulk, like ore/oil carriers. Self-unloading ships (Ships specified in **1.3.1(13), Part B**(excluding those affixed with the notation "*CSR*") and **(19)**)	Single skin hatch covers		2.0
		Double skin hatch covers	Top, side and bottom plating	2.0
			Internal structural members	1.5
		Hatch coamings, hatch coaming stays and stiffeners		1.5

Notes

(1) Corrosion additions for both sides of hatch covers and hatch coamings on non-exposed decks are to be as deemed appropriate by the Society.

(2) The definitions of Type 1 ship and Type 2 ship are given **19.1.3**.

19.2.4 Design Load for Steel Hatch Covers, Portable Beams and Hatchway Coamings

The design loads for steel hatchway covers, steel pontoon covers, steel weathertight covers, portable beams and hatchway coamings applying the requirements in **19.2** are specified in following **(1)** to **(5)**:

(1) Design vertical wave load P_{HC} (kN/m^2) is not to be less than that obtained from **Table CS19.2**. Design vertical wave loads need not to be combined with cargo loads according to **(3)** and **(4)** simultaneously.

(2) Design horizontal wave load P_A (kN/m^2) is not to be less than that obtained from the following formulae. However, P_A is not to be taken less than the minimum values given in **Table CS19.3**. P_A need not be included in the direct strength calculation of the hatch cover, expect where structures supporting stoppers are assessed.

$$P_A = f_n f_c (f_b C_1 - y)$$

f_n: As given by the following:

$20 + \frac{L'}{12}$ for unprotected front coamings and hatch cover skirt plates

$10 + \frac{L'}{12}$ for unprotected front coamings and hatch cover skirt plates, where the distance from the actual freeboard deck to the summer load line exceeds the minimum non-corrected tabular freeboard according to the ILCC by at least one superstructure standard height

$5 + \frac{L'}{15}$ for side and protected front coamings and hatch cover skirt plates

$7 + \frac{L'}{100} - 8\frac{x}{L_1}$ for aft ends of coamings and aft hatch cover skirt plates abaft amidships

$5+\frac{L'}{100}-4\frac{x}{L_1}$ for aft ends of coamings and aft hatch cover skirt plates forward of amidships

L': Length of ship L_1 (m)

L_1: Distance (m) measured on the waterline at the scantling draught d_S from the forward side of the stem to the centre of the rudder stock. L_1 is to be not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught d_S. In ships without rudder stocks (e.g. ships fitted with azimuth thrusters), the Rule length L_1 is to be taken equal to 97% of the extreme length on the waterline at the scantling draught d_S.

d_S: Scantling draught (m) at which the strength requirements for the scantlings of the ship are met and represents the full load condition; it is to be not less than that corresponding to the assigned freeboard.

C_1: As given by the following formula:

$$C_1 = 10.75 - \left(\frac{300-L_1}{100}\right)^{1.5}$$

c_L: Coefficient to be taken as 1.0

f_b: As given by the following formulae:

$$1.0+\left(\frac{0.45-\frac{x}{L_1}}{C_{b1}+0.2}\right)^2 \qquad \text{for } \frac{x}{L_1}<0.45$$

$$1.0+1.5\left(\frac{\frac{x}{L_1}-0.45}{C_{b1}+0.2}\right)^2 \qquad \text{for } \frac{x}{L_1}\geq 0.45$$

x: Distance (m) from the hatchway coamings or hatch cover skirt plates to after perpendicular, or distance from mid-point of the side hatchway coaming or hatch cover skirt plates to after perpendicular. However, where the length of the side hatchway coaming or hatch cover skirt plates exceeds 0.15 L_1, the side hatchway coaming or hatch cover skirt plates are to be equally subdivided into spans not exceeding 0.15 L_1 and the distance from the mid-point of the subdivisions to the after perpendicular is to be taken.

C_{b1}: Block coefficient. However, where C_b is 0.6 or under, 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. When determining scantlings of the aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_{b1} does not need to be taken as less than 0.8.

f_c: As given by the following formula. However, where $\frac{b'}{B'}$ is less than 0.25, $\frac{b'}{B'}$ is to be taken as 0.25.

$$0.3+0.7\frac{b'}{B'}$$

b': Breadth (m) of hatchway coamings at the position under consideration

B': Breadth (m) of ship on the exposed weather deck at the position under consideration

y: Vertical distance (m) from the designed maximum load line to the mid-point of the span of stiffeners when determining the scantlings of stiffeners and to the mid-point of the plating when determining the thickness of plating

(3) The load on hatch covers due to cargo loaded on said covers is to be obtained from the following **(a)** and **(b)**. Load cases with partial loading are also to be considered.

(a) Distributed load due to cargo load P_L (kN/m^2) resulting from heave and pitch (i.e., ship in upright condition) is to be determined according to the following formula:

$$P_L = P_{Cargo}(1+a_V)$$

P_{Cargo}: Static uniform cargo load (kN/m^2)

a_V: Vertical acceleration addition given by the following formula:

$$a_V = \frac{0.11mV'}{\sqrt{L_1}}$$

m: As given by the following formulae:

$$m_0-5(m_0-1)\frac{x}{L_1} \qquad \text{for } 0\leq\frac{x}{L_1}\leq 0.2$$

$$1.0 \qquad \text{for } 0.2<\frac{x}{L_1}\leq 0.7$$

$$1+\frac{m_0+1}{0.3}\left(\frac{x}{L_1}-0.7\right) \qquad \text{for } 0.7<\frac{x}{L_1}\le 1.0$$

m_0: As given by the following formula:

$$m_0=1.5+\frac{0.11V'}{\sqrt{L_1}}$$

V': Speed of ship (*knots*) specified in **2.1.8, Part A**. However, where V' is less than $\sqrt{L_1}$, V' is to be taken as $\sqrt{L_1}$.

x and L_1: As specified in **(2)** above

(b) Point load P (*kN*) due to a single force resulting from heave and pitch (i.e., ship in upright condition) is to be determined by the following formula. However, container loads are to comply with the provisions of **(4)** below.

$$P=P_S(1+a_V)$$

P_S: Static point load due to cargo (*kN*)

a_V: As specified in **(a)** above

(4) Where containers are stowed on hatch covers, cargo loads determined by following **(a)** to **(c)** are to be considered:

(a) Cargo loads (*kN*), acting on each corner of a container stack, due to heave, pitch and roll motion of the ship (i.e., ship in heel condition) are to be determined by the following formulae (see **Fig. CS19.1**). When the load case of a partially loaded container is considered, the cargo load is at the discretion of the Society.

$$A_Z=9.81\frac{M}{2}(1+a_V)\left(0.45-0.42\frac{h_m}{b}\right)$$

$$B_Z=9.81\frac{M}{2}(1+a_V)\left(0.45+0.42\frac{h_m}{b}\right)$$

$$B_Y=2.4M$$

M: Maximum designed mass of container stack (*t*)

$$M=\sum W_i$$

h_m: Design height of the centre of gravity of the stack above hatch cover top plates (*m*) may be calculated as the weighted mean value of the stack, where the centre of gravity of each tier is assumed to be located at the centre of each container.

$$h_m=\sum\frac{(z_iW_i)}{M}$$

z_i: Distance from hatch cover top plate to the centre of *i*th container (*m*)

W_i: Weight of *i*th container (*t*)

b: Distance between midpoints of foot points (*m*)

A_Z and B_Z: Support forces in vertical direction at the forward and aft stack corners (*kN*)

B_Y: Support force in transverse direction at the forward and aft stack corners (*kN*)

a_V: As specified in **(3)** above

(b) Details of the application of **(a)** above are to be in accordance with the following:

i) The values of A_Z and B_Z applied for the assessment of hatch cover strength are to be shown in the drawings of the hatch covers.

ii) It is recommended that container loads, as calculated in **(a)** above, be considered as the limit for foot point loads of container stacks in cargo securing (container lashing) calculations.

(c) Stack load P_{stack} (*kN*), acting on each corner of a container stack, due to heave and pitch (i.e,. ship in upright condition) is to be determined by the following formula.

$$P_{stack}=9.81\frac{M}{4}(1+a_V)$$

a_V: As specified in **(3)** above

M: As specified in **(a)** above

(5) The wave load P_{coam} to be considered in strength assessments of the hatch coaming of Type 2 ships is to be in accordance with the following **(a)** or **(b)**.

(a) Front-end hatch coaming of the foremost cargo hold: 290 (kN/m^2)

However, where a forecastle is installed in accordance with the requirements of **11.1, Part 2-3, Part C**, this value may be 220 kN/m^2.

(b) Hatch coaming other than **(a)** above: 220 (kN/m^2)

(6) In addition to the loads specified in **(1)** to **(5)** above, when the load in the ship's transverse direction by forces due to elastic deformation of the ship's hull is acting on the hatch covers, the sum of stresses is to comply with the permissible values specified in **19.2.5-1(1)**.

(7) The designed wave load $P_{stopper}$ to be considered in strength assessments of stoppers of Type 2 ships is to be in accordance with the following **(a)** or **(b)**.

(a) Stoppers for the hatch cover to the foremost cargo hold

i) Pressure acting in the direction of the stern on the front-end of the hatch cover: 230 (kN/m^2)

However, where a forecastle is installed in accordance with the requirements of **11.1, Part 2-3, Part C**, this value may be 175 kN/m^2.

ii) Pressure in the transverse direction of the ship: 175 kN/m^2

(b) Stoppers for hatch covers other than that specified in **(a)** above

Pressure acting in the direction of the stern on the front-end of the hatch cover and pressure in the transverse direction the ship: 175 kN/m^2

Table CS19.2 Design Vertical Wave Load P_{HC} (*1) (*2) (kN/m^2)

		P_{HC} (kN/m^2)
Position I	For 0.25 L_f forward	$\frac{9.81}{76}\left\{\left(4.28L_f + 28\right)\frac{x}{L_f} - 1.71L_f + 95\right\}$ (*3)
	Elsewhere	$\frac{9.81}{76}\left(1.5L_f + 116\right)$
Position II		$\frac{9.81}{76}\left(1.1L_f + 87.6\right)$

Notes:

(*1) L_f: length of ship for freeboard defined in **2.1.3, Part A** of the Rules (m)

x : distance of the mid length of the hatch cover under examination from the aft end of L_f (m)

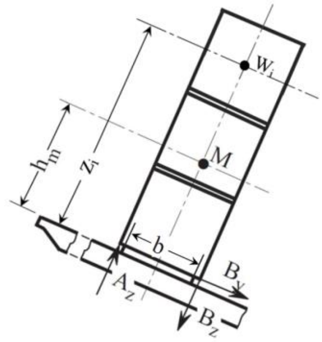
(*2) For exposed hatchways in positions other than Position I or II, the value of each design wave load will be specially considered.

(*3) Where a Position I hatchway is located at least one superstructure standard height higher than the freeboard deck, P_{HC} may be taken as $\frac{9.81}{76}\left(1.5L_f + 116\right)$ (kN/m^2).

Table CS19.3 Minimum Value of P_A (kN/m^2)

Unprotected front coamings and hatch cover skirt plates	others
$25 + \frac{L_1}{10}$	$12.5 + \frac{L_1}{20}$

Fig. CS19.1 Forces due to Container Loads



19.2.5 Strength Criteria of Steel Hatch Covers and Hatch Beams

1 Permissible stresses and deflections

(1) All hatch cover structural members are to comply with the following formulae:

$\sigma_{vm} \leq \sigma_a$ for shell elements in general.

$\sigma_{axial} \leq \sigma_a$ for rod or beam elements in general.

Where:

σ_a: Allowable stress as defined in **Table CS19.4**

σ_{vm} : Von Mises stress (N/mm^2) to be taken as follows:

$$\sigma_{vm} = \sqrt{{\sigma_x}^2 - \sigma_x\sigma_y + {\sigma_y}^2 + 3\tau_{xy}^2}$$

σ_{axial}: Axial stress (N/mm^2) in rod or beam elements

σ_x: Normal stress (N/mm^2) in the x-direction

σ_y: Normal stress (N/mm^2) in the y-direction

τ_{xy}: Shear stress (N/mm^2) in the x-y plane

x, y: Coordinates of a two dimensional Cartesian system in the plane of the considered structural element

σ_Y: Specified minimum yield stress (N/mm^2) of the material. However, when material with σ_Y of more than 355 N/mm^2 is used, the value for σ_Y is to be as deemed appropriate by the Society.

(2) The equivalent stress σ_{vm} (N/mm^2) in steel pontoon covers and hatch beams is not to be greater than $0.68\sigma_Y$, where σ_Y is as specified in **(1)** above.

(3) For FEM calculations, equivalent stress σ_{vm} (N/mm^2) in girders with unsymmetrical flanges of steel hatchway covers and steel weathertight covers is to be determined according to the following **(a)** or **(b)**:

(a) FEM calculations using the stress obtained for fine mesh elements.

(b) FEM calculations using the stress at the edge of the element or the stress at the centre of the element, whichever is greater.

(4) Deflection is to comply with following **(a)** and **(b)**:

(a) When the design vertical wave load specified in **19.2.4(1)** is acting on steel hatchway covers, steel pontoon covers, steel weathertight covers and portable beams, the vertical deflection of primary supporting members is not to be taken as more than that given by the following:

$0.0056l$ for steel hatchway covers and steel weathertight covers

$0.0044l$ for steel pontoon covers and hatch beams

l: Span of primary supporting members (m)

(b) Where hatch covers are arranged for carrying containers and mixed stowage is allowed, i.e., a 40-foot container is stowed on top of two 20-foot containers, particular attention is to be paid to the deflections of hatch covers. In addition the possible contact of deflected hatch covers with in hold cargo has to be observed.

Table CS19.4 Allowable Stresses

Members of	Subject to	σ_a (N/mm^2)
Hatch cover structure	External pressure, as defined in **19.2.4(1)**	$0.80\sigma_Y$
	Other loads, as defined in **19.2.4(2)** to **19.2.4(6)**	$0.90\sigma_Y$ for static+dynamic load case $0.72\sigma_Y$ for static load case

2 Local net plate thickness of steel hatch covers

(1) The local net thickness t_{net} (mm) of steel hatch cover top plating is not to be less than that obtained from the following formula, and it is not to be less than 1% of the spacing of the stiffeners or 6 mm, whichever is greater:

$$t_{net} = 0.0158F_p s\sqrt{\frac{P}{0.95\sigma_Y}} \text{ (mm)}$$

F_p: Coefficient given by the following formula:

$1.9\ \sigma/\sigma_a$ (for $\sigma/\sigma_a \geq 0.8$, for the attached plate flange of primary supporting members)

1.5 (for $\sigma/\sigma_a < 0.8$, for the attached plate flange of primary supporting members)

σ: Maximum normal stress (N/mm^2) of the attached plate flange of primary supporting members (see **Fig. CS19.2**).

σ_a: Permissible stress (N/mm^2) specified in **Table CS19.4**

s: Stiffener spacing (mm)

P: Design load (kN/m^2) specified in **19.2.4(1)** and **19.2.4(3)(a)**

σ_F: Minimum yield stress (N/mm^2) of the material

(2) The net thickness of double skin hatch covers and box girders is to be obtained in accordance with 5 below taking into consideration of the permissible stresses specified in **19.2.5-1(1)**.

(3) When the lower plating of double skin hatch covers is taken into account as a strength member of the hatch cover, the net thickness t_{net} (mm) of the lower plating is not to be less than 5 mm.

(4) When lower plating is not considered to be a strength member of the hatch cover, the thickness of the lower plating is to be determined as deemed appropriate by the Society.

(5) When cargo likely to cause shear buckling is intended to be carried on a hatch cover, the net thickness t_{net} (mm) is not to be less than that obtained from following formulae. In such cases, "cargo likely to cause shear buckling" refers particularly to especially large or bulky cargo lashed to the hatch cover, such as parts of cranes or wind power stations, turbines, etc. Cargo that is considered to be uniformly distributed over the hatch cover (e.g., timber, pipes or steel coils) does not need to be considered.

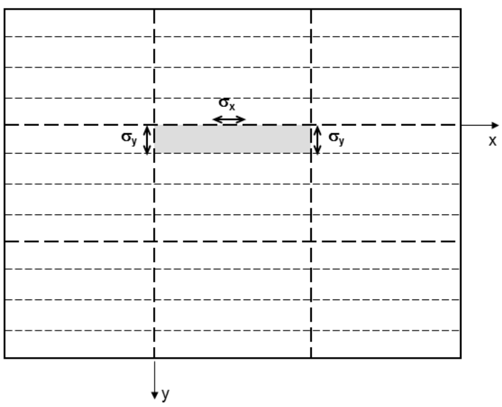
$t_{net} = 6.5s \times 10^{-3}$

$t_{net} = 5$

s: As specified in **(1)** above

Fig. CS19.2 Determination of the Normal Stress of Hatch Cover Plating

$\sigma = \max(\sigma_x; \sigma_y)$



3 Net scantling of stiffeners

(1) The net section modulus Z_{net} (cm^3) of the stiffeners of hatch cover top plates, based on stiffener net member thickness, is not to be less than that obtained from the following formula. The net section modulus of the stiffeners is to be determined based on an attached plate width that is assumed to be equal to the stiffener spacing.

$$Z_{net} = \frac{Ps\ell^2}{f_{bc}\sigma_a}\ (cm^3)$$

ℓ: Stiffener span (m) is 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 stiffener spans, the 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: Stiffener spacing (mm)

P: Design load (kN/m^2) as specified in **-2(1)** above

σ_a : Permissible stress (N/mm^2) specified in **Table CS19.4**

f_{bc}: Boundary coefficient of stiffener, taken equal to:

f_{bc} = 12, in the case of stiffener clamped at both ends.

f_{bc} = 8, in the case of stiffener simply supported at both ends or simply supported at one end and clamped at the other end

(2) The net shear sectional area A_{net} (cm^2) of the stiffener webs of hatch cover top plates is not to be less than that obtained from the following formula:

$$A_{net} = \frac{8.7SPs\ell}{\sigma_a} 10^{-3}\ (cm^2)$$

ℓ, s and P: As specified in **(1)** above

(3) Stiffeners parallel to primary supporting members are to be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members.

(4) The combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures is not to exceed the permissible stresses according to **19.2.5-1(1)**.

(5) For hatch cover stiffeners under compression, sufficient safety against lateral and torsional buckling according to **19.2.5-6** is to be verified.

(6) For stiffeners of the lower plating of double skin hatch covers, the requirements in **(1)** and **(2)** above do not need to be applied due to the absence of lateral loads and the requirements in this **-3** do not need to be applied to stiffeners in cases where the lower plating is not considered to be a strength member.

(7) The net thicknesses (mm) of a stiffener (except for U-type stiffeners) web is to not be taken as less than 4 mm.

4 Primary supporting members of steel hatch covers

(1) The scantlings of the primary supporting members of steel hatch covers and hatch beams are to be determined according to **-5** below taking into consideration the permissible stresses specified in **19.2.5-1(1)**.

(2) In addition to **(1)**, the scantlings of the primary supporting members of steel hatch cover are to comply with the requirements specified in **-6**.

(3) In addition to **(1)** and **(2)** above, net thickness t_{net} (mm) of the webs of primary supporting members is not to be less than that obtained from the following formulae, whichever is greater:

$$t_{net} = 6.5s \times 10^{-3}$$

$$t_{net} = 5$$

s: Stiffener spacing (mm)

(4) In addition to **(1)** to **(3)** above, the net thickness t_{net} (mm) of edge girders exposed to sea wash is not to be less than that obtained from the following formulae, whichever is greater:

$$t_{net} = 0.0158s\sqrt{\frac{P_A}{0.95\sigma_Y}}$$

$$t_{net} = 8.5s \times 10^{-3}$$

P_A: Design horizontal wave load (kN/m^2) as specified in **19.2.4(2)**

s: Stiffener spacing (mm)

σ_Y : Minimum yield stress (N/mm^2) of the material

5 Strength calculation

Strength calculation for hatch covers is to be carried out by using the following finite element method. Those not specified in this paragraph are to comply with the requirements in **Chapter 8, Part 1, Part C**.

(1) Loads

The design wave loads imposed on steel hatch covers are to be P_{HC} specified in **19.2.4** of the Rules.

(2) Modelling of Structures

(a) The structural model is to be able to reproduce the behaviour of the structure with the highest possible fidelity. Stiffeners and primary supporting members subject to pressure loads are to be included in the modelling. However, buckling stiffeners may be disregarded for stress calculation.

(b) Net scantlings which exclude corrosion additions are to be used for modeling.

(c) In no case is element width to be larger than stiffener spacing. The ratio of element length to width is not to exceed 3.

(d) The element height of the webs of primary supporting members is not to exceed one-third of the web height.

(e) Stiffeners may be modelled using shell elements, plane stress elements or beam elements.

(f) Hatch covers fitted with U-type stiffeners as shown in **Fig. CS19.3** are to be assessed by means of FE analysis.

(g) The geometry of the U-type stiffeners is to be accurately modelled using shell/plate elements.

(h) Nodal points are to be properly placed on the intersections between the webs of a U-type stiffener and the hatch cover plate, and between the webs and flange of the U-type stiffener.

(3) Boundary Conditions

Wherever applicable the following boundary conditions are to be applied to the FE model:

(a) Boundary nodes in way of a bearing pad on the hatch coamings are to be fixed against displacement in the direction perpendicular to the pad.

(b) Lifting stoppers are to be fixed against displacements in the direction determined by the stoppers.

(c) For a folding type hatch cover, the FE nodes connected through a hinge are to have the same translational displacement in the direction perpendicular to the hatch cover top plating.

(4) Permissible value

When the loads specified in **(1)** act on the structural model specified in **(2)**, the net scantlings are to be determined so that the stress and deflection generated in each structural member satisfy the allowable values specified in **19.2.5-1**.

(5) Miscellaneous

(a) The thickness of the top plating of steel hatch covers is to comply with the requirements in **19.2.5-2**.

(b) The scantlings of the stiffeners of steel hatch covers are to comply with the requirements in **19.2.5-3**.

(c) The buckling strength for the structural members forming steel hatch covers is to comply with the requirements in **19.2.5-6**.

(6) Additional requirements for steel hatch covers carrying cargoes

In addition to **(1)** to **(5)**, the details for steel hatch covers carrying cargoes are to comply with the following **(a)** to **(f)**:

(a) To prevent damage to hatch covers and the ship structure, the location of stoppers is to be compatible with the relative movements between hatch covers and the ship structure.

(b) Hatch covers and supporting structures are to be adequately stiffened to accommodate the load from hatch covers.

(c) At the cross-joints of multi-panel covers, vertical guides (male/female) are to be fitted to prevent excessive relative vertical deflections between loaded/unloaded panels.

(d) The construction and scantlings of hatchways on exposed parts or on the lower deck are to comply with the following requirements in addition to those of **19.2**.

i) The loading arrangement is to be clearly shown in drawings submitted for approval. In the case of freight containers, the type and location are to be additionally described.

ii) Girders or stiffeners are to be provided for reinforcement beneath the corner fittings of freight containers.

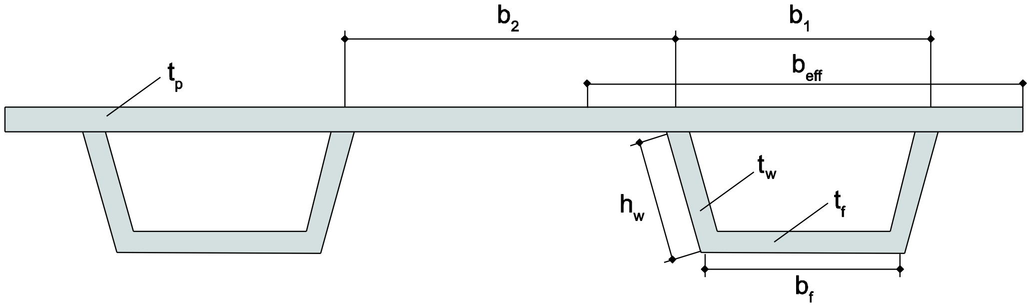
(e) The scantlings of sub structures subject to concentrated loads acting on steel hatch covers are to be determined taking into consideration the design cargo loads and permissible stresses specified in **19.2**.

(f) The top plates of hatch covers, upon which wheeled vehicles are loaded, are to comply with the following:

i) The thickness of hatch cover top plating may be determined by direct calculation or in accordance with **17.4.5**.

ii) The scantlings of the stiffeners of hatch covers may be determined by direct calculation or in accordance with **10.7.1**.

Fig. CS19.3 Example of Hatch Cover Fitted with U-type Stiffeners



6 Buckling strength of steel hatch covers

(1) Buckling assessments for hatch cover structural members are to be performed in compliance with **Annex 14.6 "Buckling Strength Assessment of Ship Structural Elements", Part 1, Part C** for the conditions specified in **19.2.5-6**. For symbols not defined in **19.2.5-6**, refer to **Annex 14.6, Part 1, Part C**.

(2) Slenderness requirements are as follows:

(a) The slenderness requirements are to be in accordance with **An2, Annex 14.6, Part 1, Part C**.

(b) Slenderness requirements need not be applied to the lower boundary of double skin hatch covers unless the cargo hold is designed for carriage of ballast or liquid cargo.

(c) 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*. However, tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

(3) Buckling assessments are to be performed for the following structural elements of hatch cover structures subjected to compressive stresses, shear stresses and lateral pressures:

- Stiffened and unstiffened panels, including curved panels and panels stiffened with U-type stiffeners.
- Web panels of primary supporting members in way of openings.

Procedures and detailed requirements for buckling assessment are given in **An4, Annex 14.6, Part 1, Part C**, including idealisation of irregular plate panels, definitions of reference stresses and buckling criteria.

(4) Panel types and assessment methods are to be accordance with the following requirements:

(a) Plate panels of hatch cover structures are to be modelled as stiffened panels (*SP*) or unstiffened panels (*UP*) as defined in **An 4.2, Annex 14.6, Part 1, Part C**. In addition, Method A (-A) and Method B (-B) as defined in **An1.3, Annex 14.6, Part 1, Part C** are to be used in accordance with **Table CS19.5**, **Fig. CS19.4** and **Fig. CS19.5**, while the procedures for openings are to be used for buckling assessments of web panels with openings.

(b) Hatch covers fitted with U-type stiffeners are also to be in accordance with the additional buckling assessment requirements specific for panels with U-type stiffeners in **An5.2.5, Annex 14.6, Part 1, Part C**.

(5) Buckling assessments of hatch covers are based on lateral pressure as defined in **19.2.4-1(1)**, **19.2.4-1(2)** and **19.2.4-1(5)**, and stresses obtained from FE analyses (*See* **19.2.5-5)**.

(6) The safety factor for hatch cover structural members is to be taken as *S*=1.0 for the plating and stiffener buckling capacity formulae defined in **An5.2.2** and **An5.2.3**, **Annex 14.6, Part 1, Part C** respectively.

(7) The buckling strength of structural members is to be in accordance with the following formula:

$$\eta_{act} \leq \eta_{all}$$

Where:

η_{act}: Buckling utilisation factor based on applied stress, as defined in **An1.3.2.2** and **An4, Annex 14.6, Part 1, Part C**, and calculated per **An5, Annex 14.6, Part 1, Part C.**

η_{act}: Allowable buckling utilisation factor, as given in **Table CS19.6**

Table CS19.5 Structural Members and Assessment Methods

Structural elements	Assessment method[1][2]	Normal panel definition
Hatch cover top/bottom plating structures, see **Fig. CS19.4**		
Hatch cover top/bottom plating	SP-A	Length: between transverse girders Width: between longitudinal girders
Irregularly stiffened panels	UP-B	Plate between local stiffeners/PSM
Hatch cover web panels of primary supporting members, see **Fig. CS19.5**		
Web of transverse/longitudinal girder (single skin type)	UP-B	Plate between local stiffeners/face plate/PSM
Web of transverse/longitudinal girder (double skin type)	SP-B[3]	Length: between PSM Width: full web depth
Web panel with opening	Procedure for opening	Plate between local stiffeners/face plate/PSM
Irregularly stiffened panels	UP-B	Plate between local stiffeners/face plate/PSM

Note 1: SP and UP stand for stiffened and unstiffened panel respectively.
Note 2: A and B stand for Method A and Method B respectively.
Note 3: In case that the buckling carlings/brackets are irregularly arranged in the web of transverse/longitudinal girder, UP-B method may be used.

Fig. CS19.4 Hatch Cover Top/Bottom Plating Structures

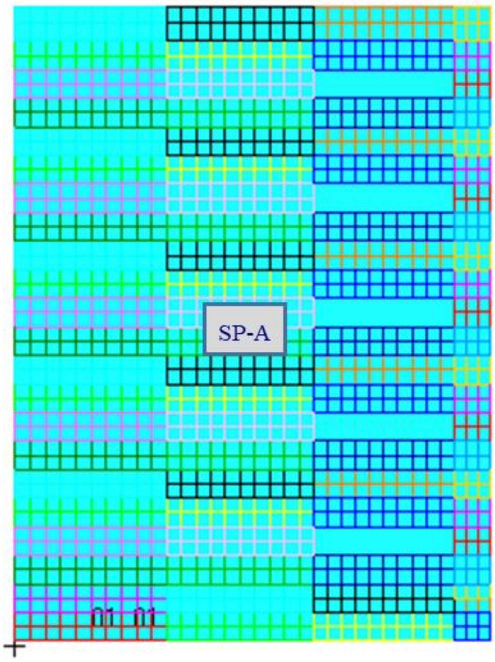


Fig. CS19.5 Hatch Cover Webs of Primary Supporting Members

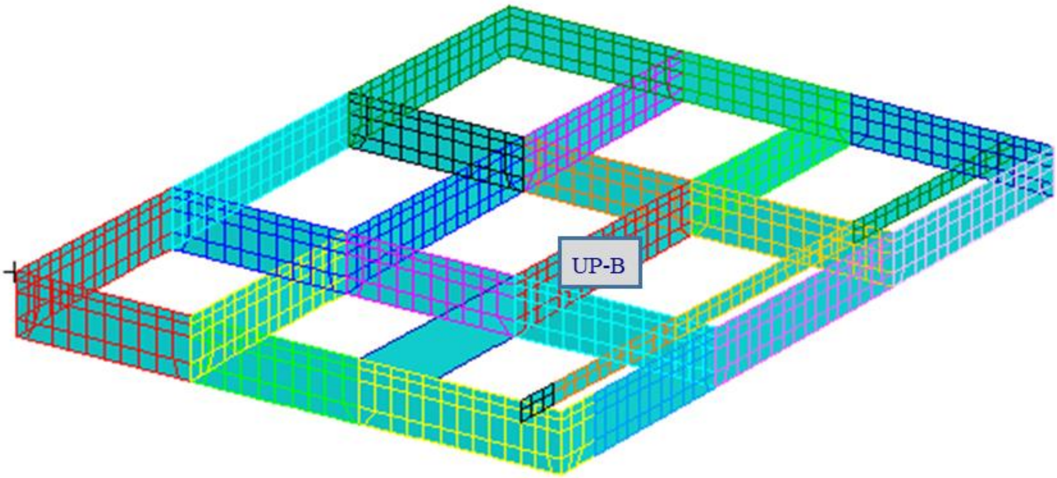


Table CS19.6 Allowable Buckling Utilisation Factors

Structural component	Subject to	η_{all}, Allowable buckling utilisation factor
Plates and stiffeners Web of PSM	External pressure, as defined in **19.2.4-1(1)**	0.80
	Other loads, as defined in **19.2.4-1(2)** to **19.2.4-1(6)**	0.90 for static+dynamic load case 0.72 for static load case

19.2.6 (Deleted)

19.2.7 Portable Beams, Hatchway Covers, Steel Pontoon Covers and Steel Weathertight Covers

1 Portable beams are to comply with the following **(1)** to **(8)**:

(1) The carriers and sockets for portable beams are to be of substantial construction, having a minimum beaming surface of 75 *mm*, and are to be provided with means for the efficient fitting and securing of the beams.

(2) Coamings are to be stiffened in way of carriers and sockets by providing stiffeners from these fittings to the deck or by equivalent strengthening.

(3) Where beams of a sliding type are used, the arrangement is to ensure that the beams remain properly in position when the hatchway is closed.

(4) The depth of portable beams and the width of their face plates are to be suitable to ensure the lateral stability of the beams. The depth of beams at their ends is not to be less than 0.40 *times* the depth at their mid-point or 150 *mm*, whichever is greater.

(5) The upper face plates of portable beams are to extend to the ends of the beams. The web plates are to be increased in thickness to at least twice that at the mid-point for at least 180 *mm* from each end or to be reinforced with doubling plates.

(6) Portable beams are to be provided with suitable gear for releasing them from slings without the need for personnel to get on the beam.

(7) Portable beams are to be clearly marked to indicate the deck, hatchway and position to which they belong.

(8) Scantling of hatch beam with variable cross-sections is to be not less than that obtained from the following formulae.

The net section modulus (cm^3) of hatch beams at the mid-point

$Z_{net} = Z_{net_{cs}}$

$Z_{net} = k_1 Z_{net_{cs}}$

The net moment of inertia (cm^4) of hatch beams at the mid-point

$I_{net} = I_{net_{cs}}$

$I_{net} = k_2 I_{net_{cs}}$

$Z_{net_{cs}}$: Net section modulus (cm^3) complying with requirement **19.2.5-4(1)**

$I_{net_{cs}}$: Net moment of inertia (cm^4) complying with requirement **19.2.5-4(1)**

S : Spacing (m) of portable beams

ℓ : Unsupported span (m) of portable beams

b : Width (m) of steel hatch covers

k_1 and k_2 : Coefficients obtained from the formulae given in **Table CS19.7**

Table CS19.7 Coefficient k_1 and k_2

k_1	$1+\dfrac{3.2\alpha-\gamma-0.8}{7\gamma+0.4}$	k_1 is not to be taken as less than 1.0 $\alpha=\dfrac{\ell_1}{\ell},\ \beta=\dfrac{I_1}{I_0},\ \gamma=\dfrac{Z_1}{Z_0}$
k_2	$1+8\alpha^3\dfrac{1-\beta}{0.2+3\sqrt{\beta}}$	

ℓ : Overall length of hatch beam (m)

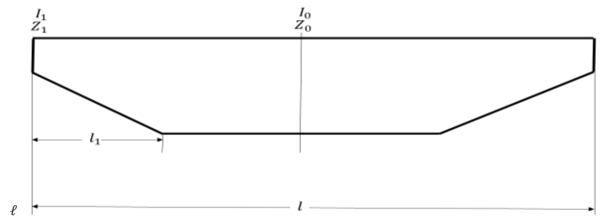
ℓ_1 : Distance from the end of parallel part to the end of portable beam (m)

I_0 : Moment of inertia at mid-span (cm^4)

I_1 : Moment of inertia at ends (cm^4)

Z_0 : Section modulus at mid-span (cm^3)

Z_1 : Section modulus at ends (cm^3)



2 Hatchway covers are to comply with the following **(1)** to **(5)**:

(1) Hatch rests are to be provided with at least a 65 mm bearing surface and are to be bevelled, if required, to suit the slope of the hatchways.

(2) Hatchway covers are to be provided with suitable hand grips according to their weight and size, except where such grips are unnecessary due to the cover's construction.

(3) Hatchway covers are to be clearly marked to indicate the deck, hatchway and position to which they belong.

(4) The wood for hatchway covers is to be of good quality, straight grained and reasonably free from knots, sap and shakes.

(5) The ends of all wood covers are to be protected by an encircling steel band.

3 Steel pontoon covers are to comply with the following **(1)** to **(3)**:

(1) The depth of steel pontoon covers at the supports is not to be less than one-third the depth at the mid-point or 150 mm, whichever is greater.

(2) The width of bearing surface for steel pontoon covers is not to be less than 75 mm.

(3) Steel pontoon covers are to be clearly marked to indicate the deck, hatchway and position to which they belong.

4 Steel weathertight covers are to comply with the following.

(1) The depth of steel weathertight covers at the supports is not to be less than one-third the depth at mid-span or 150 mm, whichever is greater.

19.2.8 Tarpaulins and Securing Arrangements for Hatchways Closed by Portable Covers

1 At least two layers of tarpaulins of Grade A complying with the requirements in **Chapter 6, Part L** are to be provided for each exposed hatchway on the freeboard or superstructure decks and at least one layer of such a tarpaulin is to be provided for each exposed hatchway elsewhere.

2 Battens are to be efficient for securing the tarpaulins and not to be less than 65 mm in width and 9 mm in thickness.

3 Wedges are to be of tough wood or other equivalent materials. They are to have a taper not more than 1/6 and not to be less than 13 mm in thickness at the point.

4 Cleats are to be set to fit the taper of the wedges. They are to be at least 65 mm wide and to be spaced not more than 600 mm from centre to centre; the cleats along each side are to be arranged not more than 150 mm apart from the hatch corners.

5 For all hatchways in exposed freeboard and superstructure decks, steel bars or other equivalent means are to be provided in order to efficiently secure each section of the hatchway cover after the tarpaulins are battened down. Hatchway covers of more than 1.5 *metres* in length are to be secured by at least two such securing appliances. At all other hatchways in exposed positions on weather decks, ring bolts or other suitable fittings for lashing are to be provided.

19.2.9 Hatch Coaming Strength Criteria

1 Height of coamings is to comply with following **(1)** to **(3)**:

(1) Height of coamings above the upper surface of the deck is to be at least 600 *mm* in Position I and 450 *mm* in Position II.

(2) For hatchways closed by weathertight steel hatch covers, the height of coamings may be reduced from that prescribed in **(1)** or omitted entirely subject to the satisfaction of the Society.

(3) The height of hatchway coamings other than those provided in exposed portions of the freeboard or superstructure decks is to be to the satisfaction of the Society having regard to the position of hatchways or the degree of protection provided.

2 Scantlings of hatch coamings are to be in accordance with the followings.

(1) The local net plate thickness (*mm*) of the hatch coaming plating $t_{coam,net}$ is not to be less than that obtained from following formula in **(a)** or **(b)**:

(a) For Type 1 ships

$$t_{coam,net} = 0.0142s\sqrt{\frac{P_A}{0.95\sigma_Y}}\ (mm),\quad \text{but not to be less than } 6 + \frac{L'}{100}\ (mm)$$

s: Stiffener spacing (*mm*)

P_A: As specified in **19.2.4(2)**

σ_Y : Minimum yield stress (N/mm^2) of the material

L': Length of ship L_1 (m)

(b) For Type 2 ships

$$t_{coam,net} = 0.016s\sqrt{\frac{P_{coam}}{0.95\sigma_Y}}\ (\text{mm}),\quad \text{but not to be less than } 9.5\ (mm)$$

P_{coam} : As specified in **19.2.4(5)**

s and σ_Y : As specified in **(a)** above

(2) For Type 1 ships, where the hatch coaming stiffener is snipped at both ends, gross thickness $t_{coam,gross}$ (mm) of the coaming plate at the sniped stiffener end is not to be less than that obtained from the following formula:

$$t_{coam,gross} = 19.6\sqrt{\frac{P_A s(\ell - 0.0005s)}{1000\sigma_Y}}\ (\text{mm})$$

ℓ: Stiffener span (m) to be taken as the spacing of coaming stays

s, P_A and σ_Y: As specified in **(1)** above

(3) The net section modulus Z_{net} (cm^3) and net shear area (cm^2) of hatch coaming stiffeners are not to be less than that obtained from the following formula.

(a) For Type 1 ships

$$Z_{net} = \frac{P_A s l^2}{f_{bc}\sigma_Y}\ (cm^3)$$

$$A_{net} = \frac{P_A s \ell}{\sigma_Y}10^{-2}\ (cm^2)$$

s, ℓ, P_A and σ_Y: As specified in **(2)** above

f_{bc} : Coefficient according to the type of end connection of stiffeners given by the following formula:

f_{bc} = 12 with both ends constant

= 8 for the end spans of stiffeners sniped at the coaming corners

For sniped stiffeners of coaming at hatch corners shear area obtained from the above formula has to be increased by 35%.

(b) For Type 2 ships

$$Z_{net} = 1.21\frac{P_{coam}s\ell^2}{f_{bc}c_p\sigma_Y}\ (cm^3)$$

f_{bc} : Coefficient according to the type of end connection of stiffeners given by the following formula:

f_{bc} = 16 with both ends constant

= 12 for the end spans of stiffeners sniped at the coaming corners

c_p = Ratio of the plastic section modulus to the elastic section modulus of the stiffeners with an attached plate breadth

(mm) equal to $40t_{coam,net}$, where $t_{coam,net}$ is the plate net thickness

= 1.16 in the absence of more precise evaluation

s, ℓ, $and\ \sigma_Y$: As specified in **(2)** above

P_{coam} : As specified in **19.2.4(5)**

(4) Buckling strength assessment of hatch coaming is to be carried out by the method as deemed appropriate by the Society.

(5) The net scantlings of hatch coaming stays are to be in accordance with following **(a)** to **(c)** and coaming stays are to be designed for the loads transmitted through them and permissible stresses according to **19.2.5-1**.

(a) For hatch coaming stays considered to be simple beams (see **Examples 1 and 2 of Fig. CS19.6**), the net section modulus Z_{net} (cm^3) of such stays at their deck connections and the net scantling $t_{w,net}$ (mm) of their webs are not to be less than that obtained from following formulae.

$$Z_{net} = \frac{{H_C}^2 s_C P}{1.9\sigma_Y}\ (cm^3)$$

$$t_{w,net} = \frac{2H_C s_C P}{\sigma_Y h}\ (mm)$$

H_C: Hatch coaming stay height (m)

h: Hatch coaming stay depth (mm)

s_C: Hatch coaming stay spacing (mm)

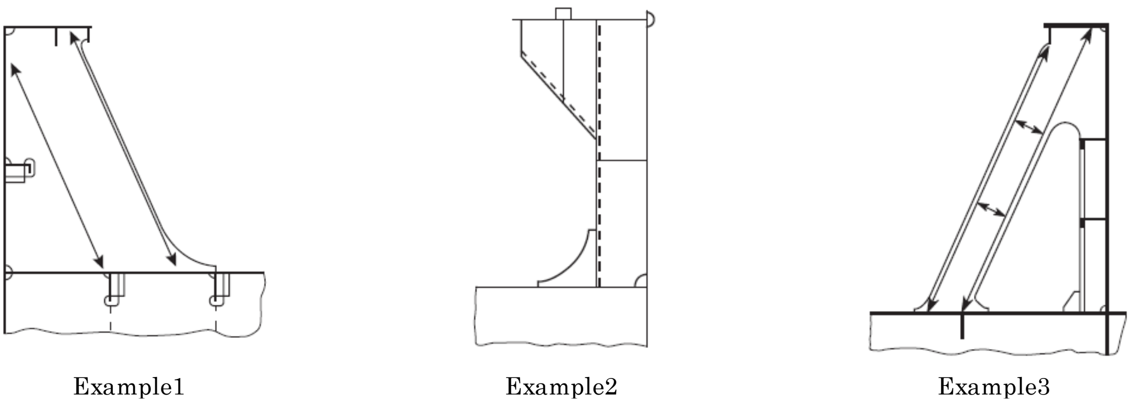
σ_Y: As specified in **(1)** above

P : Pressure (kN/m^2) on coaming taken as P_A defined in **19.2.4(2)** for Type 1 ships and as P_{Coam} defined in **19.2.4(5)** for Type 2 ships.

(b) For coaming stays other than those in **(a)** above (see **Example 3 of Fig. CS19.6**), the stresses are generally to be determined through FEM, and the calculated stresses are to satisfy the permissible stress criteria of **19.2.5-1**.

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

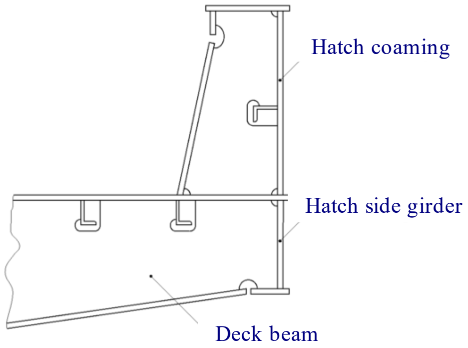
Fig. CS19.6 Examples of Coaming Stays



3 Coamings are to be additionally supported by efficient brackets or stays provided from the horizontal stiffeners to the deck at intervals of approximately 3 metres.

4 Coaming plates are to extend to the lower edge of the deck beams or hatch side girders are to be fitted that extend to the lower edge of the deck beams (see **Fig. CS19.7**). Extended coaming plates and hatch side girders are to be flanged or fitted with face bars or half-round bars, except where specially approved by the Society.

Fig. CS19.7 Example for the Extension of Coaming Plates



5 Hatch coamings and hatch coaming stays are to comply with the following requirements:

(1) The local details of the structures are to be designed so as to transfer pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

(2) Underdeck structures are to be checked against the load transmitted by the stays.

(3) 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 $0.44t_{w,gross}$, where $t_{w,gross}$ is the gross thickness of the stay web.

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

(5) On ships carrying cargoes such as timber, coal or coke on deck, the stays are to be spaced not more than 1.5 *m* apart.

(6) Hatch coaming stays are to be supported by appropriate substructures.

(7) For hatch coamings that transfer friction forces at hatch cover supports, special consideration is to be given to fatigue strength.

(8) Longitudinal hatch coamings with a length exceeding 0.1 L_1 are to be provided with tapered brackets or equivalent transitions and a corresponding substructure at both ends. At the end of the brackets, they are to be connected to the deck by full penetration welds of minimum 300 *mm* in length.

(9) Hatch coamings and horizontal stiffeners on hatch coamings may be considered as a part of the longitudinal hull structure when designed according to the requirements for longitudinal strength and verified in cases deemed appropriate by the Society.

(10) Unless otherwise specified, the material and welding requirements for hatch coamings are to comply with the provisions of other Parts of the Rules.

19.2.10 Closing Arrangements

1 Securing devices

(1) Securing devices between covers and coamings and at cross-joints are to ensure weathertightness.

(2) The means for securing and maintaining weathertightness by using gaskets and securing devices are to comply with the following **(a)** to **(f)**. The means for securing and maintaining weathertightness of weathertight covers are to be to the satisfaction of the Society. Arrangements are to ensure that weathertightness can be maintained in any sea condition.

(a) The weight of covers and any cargo stowed thereon are to be transmitted to the ship structure.

(b) Gaskets and compression flat bars or angles which are arranged between covers and the ship structure and cross-joint elements are to be in compliance with the following **i)** to **iv)**:

i) Compression bars or angles are to be well rounded where in contact with the gaskets and are to be made of corrosion-resistant materials.

ii) The gaskets are to be of relatively soft elastic materials. The material is to be of a quality suitable for all environmental conditions likely to be experienced by the ship, and is to be compatible with the cargoes carried.

iii) A continuous gasket is to be effectively secured to the cover. The material and form of gasket selected are to be considered in conjunction with the type of cover, the securing arrangement and the expected relative movement between the cover and ship structure.

iv) The specification or grade of the packing material is to be indicated on the drawings.

(c) Securing devices attached to hatchway coamings, decks or covers are to be in compliance with the following **i)** to **vi)**:

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

ii) The moment of inertia (cm^4) of the edge elements of hatch covers is not to be less than that obtained from the following formula:

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

a : Spacing (m) between securing devices, not to be taken less than 2 m

p : Packing line pressure (N/mm), minimum 5 N/mm

iii) The gross sectional area (cm^2) of each securing device is not to be less than that obtained from the following formula. However, rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 m^2 in area.

$A = 0.28ap/f$

f: As obtained from the following formula:

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

σ_Y : Minimum yield stress (N/mm^2) of the steel used for fabrication, but not to be taken greater than 70% of the ultimate tensile strength

e : A coefficient determined according to the value of σ_Y, as follows:

1.0 for $\sigma_Y \leq 235\ N/mm^2$

0.75 for $\sigma_Y > 235\ N/mm^2$

a and p: As specified in **(ii)** above

iv) Individual securing devices on each cover are to have approximately the same stiffness characteristics.

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

vi) 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.

(d) A drainage arrangement equivalent to the standards specified in the following is to be provided.

i) Drainage is to be arranged inside the line of gaskets by means of a gutter bar or vertical extension of the hatch side and end coaming. If an application is made by the owner of a container carrier and the Society deems it to be appropriate, special consideration will be given to this requirement.

ii) Drain openings are to be arranged at the ends of drain channels and are to be provided with effective means such as non-return valves or the equivalent for preventing the ingress of water from outside.It is unacceptable to connect fire hoses to the drain openings for this purpose.

iii) Cross-joints of multi-panel covers are to be arranged with a drainage channel for water from space above the gasket and a drainage channel below the gasket.

iv) If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket is also to be provided for.

v) Drain openings in hatch coamings are to be arranged with sufficient distance to areas of stress concentration (e.g. hatch corners, transitions to crane posts).

(e) It is recommended that ships with steel weathertight covers are supplied with an operation and maintenance manual which includes the following **i)** to **v)**:

i) Opening and closing instructions

ii) Maintenance requirements for packing, securing devices and operating items

iii) Cleaning instructions for drainage systems

iv) Corrosion prevention instructions

v) List of spare parts

(f) Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to **-2** below. The packing line pressure q is to be specified, and as load, q multiplied by the spacing between securing devices a (m) is to be applied.

2 The securing devices of hatch covers, on which cargo is to be lashed, are to be designed for a lifting force resulting from the loads according to **19.2.4(4)** (see **Fig. CS19.8**). Unsymmetrical loading, which may occur in practice, is to be considered. Under such loading, the equivalent stress (N/mm^2) in securing devices is not to be greater than that obtained from the following formula. Anti-lifting devices may be dispensed with at the discretion of the Society.

$$\sigma_E = \frac{150}{k_l}$$

k_l: As obtained from the following formula:

$$k_l = \left(\frac{235}{\sigma_Y}\right)^e$$

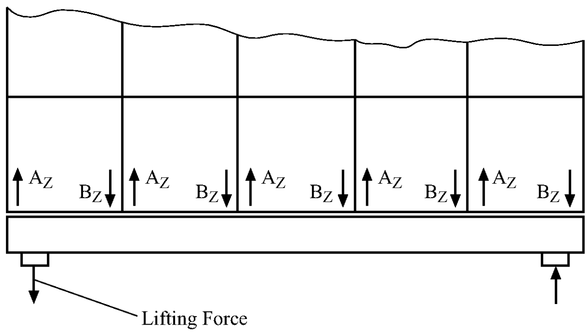
σ_Y : Minimum yield stress (N/mm^2) of the material

e: As given below

0.75 for $\sigma_Y > 235$

1.00 for $\sigma_Y \leq 235$

Fig. CS19.8 Lifting Forces at a Hatch Cover



19.2.11 Hatch Cover Supports, Stoppers and Supporting Structures

1 Hatch cover supports, stoppers and supporting structures subject to the provisions of **19.2** are to comply with the following **(1)** to **(3)**:

(1) For the design of the securing devices for the prevention of shifting, the horizontal mass forces F obtained from the following formula are to be considered. Acceleration in the longitudinal direction, a_X, and in the transverse direction, a_Y, does not need to be considered as acting simultaneously.

$$F = ma$$

m: Sum of mass of cargo lashed on the hatch cover and mass of hatch cover

a: Acceleration obtained from the following formula

$a_X = 0.2g$ for longitudinal direction

$a_Y = 0.5g$ for transverse direction

(2) The design load for determining the scantlings of stoppers is not to be less than that obtained from **19.2.4(2)** and **(1)**, whichever is greater. Stress in the stoppers is to comply with the criteria specified in **19.2.5-1(1)**.

(3) The details of hatch cover supporting structures are to be in accordance with the following **(a)** to **(g)**:

(a) The nominal surface pressure (N/mm^2) of a hatch cover supports is not to be greater than that obtained from the following formula:

$P_{n\,max} = dP_n$ in general

$P_{n\,max} = 3P_n$ for metallic supporting surface not subjected to relative displacements

d: As given by the following formula. Where d exceeds 3, d is to be taken as 3.

$$d = 3.75 - 0.015L_1$$

$d_{\min} = 1.0$ in general

$d_{\min} = 2.0$ for partial loading conditions

L_1: Distance (m) measured on the waterline at the scantling draught d_S from the forward side of the stem to the centre of the rudder stock. L_1 is to be not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught d_S. In ships without rudder stocks (e.g. ships fitted with azimuth thrusters), the Rule length L_1 is to be taken equal to 97% of the extreme length on the waterline at the scantling draught d_S.

d_S: Scantling draught (m) at which the strength requirements for the scantlings of the ship are met and represents the full load condition; it is to be not less than that corresponding to the assigned freeboard.

P_n: As obtained from **Table CS19.8**

(b) Where large relative displacements of the supporting surfaces are to be expected, the use of material having low wear and frictional properties is recommended.

(c) Drawings of the supports are to be submitted. In these drawings, the permitted maximum pressure given by the material manufacturer is to be specified.

(d) When the manufacturer of the vertical hatch cover support material can provide proof that the material is sufficient for the increased surface pressure, not only statically but under dynamic conditions, the permissible nominal surface pressure $P_{n\ max}$, as specified in **(a)** above, may be relaxed at the discretion of the Society. However, realistic long term distributions of spectra for vertical loads and relative horizontal motion between hatch covers and hatch cover stoppers are as deemed appropriate by the Society.

(e) Irrespective of the arrangement of stoppers, the supports are to be able to transmit the following force P_h in the longitudinal and transverse direction.

$$P_h = \mu \frac{P_V}{\sqrt{d}}$$

P_V: Vertical supporting force

μ: Friction coefficient generally to be taken as 0.5. For non-metallic or low-friction materials, the friction coefficient may be reduced as appropriate by the Society. However, in no case μ is to be less than 0.35.

(f) Stresses in supporting structures are to comply with the criteria specified in **19.2.5-1(1)**.

(g) For substructures and adjacent constructions of supports subjected to horizontal forces P_h, special consideration is to be given to fatigue strength.

Table CS19.9 Strength Requirements for Stoppers

Design pressure	As specified in **19.2.4(7)**.
Allowable equivalent stress	In stoppers, their supporting structures and the stopper welds (calculated at the throat of welds), the equivalent stress is not to exceed the allowable value of 0.8 times the yield stress of the material.

Table CS19.8 Permissible Nominal Surface Pressure P_n

Material	P_n when loaded by	
	Vertical force	Horizontal force (on stoppers)
Hull structure steel	25	40
Hardened steel	35	50
Lower friction materials	50	-

2 For steel weathertight hatch covers of Type 2 ships, effective means for stoppers complying with the requirements in **Table CS19.9** against the horizontal green sea forces acting on them are to be provided.

19.2.12 Steel Hatchway Covers for Container Carriers

1 For container carriers with unusually large freeboards, gaskets and securing devices for steel hatchway covers may be suitably dispensed with at the discretion of the Society upon request by the applicant for classification.

2 Treatment of towage and segregation of containers containing dangerous goods is to be at the discretion of the Society.

19.2.13 Additional Requirement for Small Hatches Fitted on Exposed Fore Deck

For ships of 80 m or more in length L_c, specified in **1.4.3.1-1, Part 1, Part C**, small hatches located on exposed decks forward of 0.25 L_c are to be of sufficient strength and weathertightness to resist green sea force if the height of the exposed deck in way of those hatches is less than 0.1 L_c or 22 *m* above the designed maximum load line, whichever is smaller.

19.3 Machinery Space Openings

19.3.1 Protection of Machinery Space Openings

Machinery space openings are to be enclosed by steel casings.

19.3.2 Exposed Machinery Space Casings

1 Exposed machinery space casings are to have scantlings not less than those required in **18.2.1** and **18.2.2** taking the *c* value as 1.0.

2 The thickness of the top plating of exposed machinery space casing is not to be less than that obtained from the following formulae:

Position I: $6.3S + 2.5$ (mm)

Position II: $6.0S + 2.5$ (mm)

Where:

S: Spacing of stiffeners (m)

19.3.3 Machinery Space Casings below Freeboard Deck or within Enclosed Spaces

The scantlings of machinery space casings below the freeboard deck or within enclosed superstructures or deckhouses are to comply with the following requirements:

(1) The thickness of the plating is to be at least 6.5 mm; where the spacing of stiffeners is greater than 760 mm, the thickness is to be increased at the rate of 0.5 mm per 100 mm excess in spacing. In accommodation spaces, the thickness of the plating may be reduced by 2 mm.

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

$1.2Sl^3$ (cm^3)

Where:

l: Tween deck height (m)

S: Spacing of stiffeners (m)

19.3.4 Access Openings to Machinery Spaces

1 All access openings to machinery spaces are to be located in protected positions as far as possible and provided with steel doors capable of being closed and secured from both sides. Such doors in exposed machinery space casings on the freeboard deck are to comply with the requirements in **18.3.1-1**.

2 The sills of doorways in machinery space casings are not to be less than 600 mm in height above the upper surface of the deck in Position I and 380 mm in Position II.

3 In ships having a reduced freeboard, doorways in the exposed machinery space casings on the freeboard or raised quarter deck are to lead to a space or passageway which is of a strength equivalent to that of the casing and is separated from the stairway to the machinery spaces by a second steel weathertight door of which the doorway sill is to be at least 230 mm in height.

19.3.5 Miscellaneous Openings in Machinery Space Casing

1 Coamings of any fiddley, funnel and machinery space ventilator in an exposed position on the freeboard or superstructure deck are to be as high above the deck as reasonable and practicable.

2 In exposed positions on the freeboard and superstructure decks, fiddley openings and all other openings in the machinery space casings are to be provided with strong steel weathertight covers permanently fitted in their proper positions.

3 Annular spaces around funnels and all other openings in the machinery space casings are to be provided with a means of closing capable of being operated from outside the machinery space in case of fire.

19.3.6 Machinery Space Casings within Unenclosed Superstructure or Deckhouses

Machinery space casings within unenclosed superstructures or deckhouses and doors provided thereon are to be constructed to the satisfaction of the Society, having regard to the degree or protection afforded by the superstructure or deckhouse.

19.4 Companion-ways and Other Deck Openings

19.4.1 Manholes and Flush Scuttles

Manholes and flush scuttles in exposed positions on the freeboard and superstructure decks or within superstructures other than enclosed superstructures are to be closed by steel covers capable of being made watertight. These covers are to be secured by closely spaced bolts or to be permanently fitted.

19.4.2 Companion-ways

1 Access openings in the freeboard deck are to be protected by enclosed superstructures, or by deckhouses or companion-ways of equivalent strength and weathertightness.

2 Access openings in exposed superstructure decks or in the top of deckhouses on the freeboard deck which give access to a space below the freeboard deck or a space within an enclosed superstructure are to be protected by efficient deckhouses or companion-ways.

3 Doorways in deckhouses or companion ways such as specified in **-1** and **-2** are to be provided with doors complying with the requirements in **18.3.1-1**.

4 The sills of doorways in companionways specified in **-1** to **-3** are not to be less than 600 *mm* in height above the upper surface of the deck in Position I and 380 *mm* in Position II.

5 For deckhouses or superstructures which protect access openings to spaces below the freeboard deck, the height of sills of doorways on the freeboard deck are not to be less than 600 *mm*. However, where access is provided from the deck above as an alternative to access from the freeboard deck, the height of sills into a bridge or poop or deckhouse may be reduced to 380 *mm*.

6 Where the access openings in superstructures and deckhouses which protect access openings to spaces below the freeboard deck do not have closing appliances in accordance with the requirements of **18.3.1-1**, the openings to spaces below the freeboard deck are to be considered exposed.

19.4.3 Openings to Cargo Spaces

Access and other openings to cargo spaces are to be provided with a means of closing capable of being operated from outside the spaces in case of fire. Such closing means for any opening leading to any other space inboard the ship is to be of steel.

Chapter 20 MACHINERY SPACES, BOILER ROOMS AND TUNNEL RECESSES

20.1 General

20.1.1 Application

The construction of machinery spaces is to be in accordance with the requirements in the relevant Chapters, in addition to this Chapter.

20.1.2 Construction*

Machinery spaces are to be sufficiently strengthened by means of web frames, strong beams and pillars or other arrangements.

20.1.3 Supporting Structures for Machinery and Shafting

All parts of the machinery and shafting are to be efficiently supported and the adjacent structures are to be adequately stiffened.

20.1.4 Twin Screw Ships and Those with High Power Engines

In twin screw ships and those with high power engines, the structure and attachments of the engines' foundations are to be especially strengthened in relation to the engines' proportions, weight, power, type, etc.

20.2 Main Engine Foundations

20.2.1 Ships with Single Bottoms*

1 In ships with single bottoms, the main engines are to be seated upon thick rider plates laid across the top of deep floors or heavy foundation girders efficiently bracketed and stiffened and having sufficient strength in proportion to the power and size of the engines.

2 The main lines of bolting that hold down the main engines to the rider plates mentioned in **-1** are to pass through the rider plates into the girder plates provided underneath.

3 In ships with longitudinal girders of not excessive spacing beneath the engine which is on the centre line of the hull, the centre keelson may be omitted for the section where the engine is located.

20.2.2 Ships with Double Bottoms

1 In ships with double bottoms, the main engines are to be seated directly upon thick inner bottom plating or thick seat plates on the top of heavy foundations so arranged as to effectively distribute the weight.

2 Additional side girders are to be provided within the double bottom beneath the main lines of bolting and other suitable positions so as to ensure satisfactory distribution of the weight and rigidity of the structure.

20.3 Construction of Boiler Rooms

20.3.1 Boiler Foundations

1 Boilers are to be supported by deep saddle shape floors or by transverse or longitudinal girders so arranged as to effectively distribute the weight.

2 Where boilers are supported by transverse saddles or girders, the floors in way of same are to be especially stiffened.

20.3.2 Boiler Location

Boilers are to be so placed as to ensure accessibility and proper ventilation.

20.3.3 Clearance between Boilers and Adjacent Structures

1 Boilers are to be at least 457 *mm* clear of adjacent structures such as tank tops. The thickness of adjacent members is to be increased as may be required where the clearance is unavoidably less. The available clearance is to be indicated on the plans submitted for approval.

2 Hold bulkheads and decks are to be kept well clear of the boilers and uptakes, or provided with suitable insulating arrangements.

3 Side sparrings are to be provided on the bulkheads adjacent to the boilers, keeping suitable clearance on their hold sides.

20.4 Thrust Blocks and Foundations

20.4.1 Thrust Foundations

Thrust blocks are to be bolted to efficient foundations extending well beyond the thrust blocks and so arranged as to effectively distribute the loads into the adjacent structures.

20.4.2 Construction under Thrust Foundations

Additional girders are to be provided in way of the foundations, as necessary.

20.5 Plummer Blocks and Auxiliary Machinery Seats

20.5.1 General

Plummer blocks and auxiliary machinery seats are to be of ample strength and stiffeness in proportion to the weight supported and the height of the foundations.

20.6 Tunnels and Tunnel Recesses

20.6.1 Arrangement

1 In ships with machinery amidships, the shafting is to be enclosed by a watertight tunnel of sufficient dimensions.

2 Watertight doors are to be provided at the fore end of tunnel. The means of closing and construction of the watertight doors are to be as required in **13.3**.

3 In tunnels which are provided with watertight doors in accordance with the requirements in **-2**, escape trunks are to be provided at a suitable location and they are to lead to the bulkhead deck or above.

20.6.2 Flat Side Plating

The thickness of plating on flat sides of the tunnel is not to be less than that obtained from the following formula:

$$2.9S\sqrt{h} + 2.5 \ \ (mm)$$

Where:

S: Spacing of stiffeners (m)

h: Vertical distance (m) at the mid-length of each hold from the lower edge of the side wall plating to the bulkhead deck at the centre line of the ship

20.6.3 Flat Top Plating

1 The thickness of flat plating of the top of tunnels or tunnel recesses is not to be less than that obtained from the formula in **20.6.2**, h being taken as the height from the top plates to the bulkhead deck at the centre line of the ship.

2 Where the top of tunnels or tunnel recesses forms part of the deck, the thickness is to be increased by at least one mm above that obtained from the requirements in **-1**, but it is not to be less than that required for the deck plating at the same position.

20.6.4 Curved Top or Side Plating

The thickness of curved top or side plating is to be determined by the requirements in **20.6.2** using a stiffener spacing reduced by 150 mm from the actual spacing.

20.6.5 Top Plating under Hatchways

Top plating of tunnel under hatchways is to be increased by at least 2 mm or to be protected by wood sheathing of not less than 50 mm in thickness.

20.6.6 Wood Sheathings

The wood sheathing mentioned in **20.6.5** is to be so secured as to keep watertightness of the tunnel where it might be damaged by cargo. Similar consideration is to be taken where structures such as ladder steps are provided in the tunnels.

20.6.7 Stiffeners

1 Stiffeners are to be provided not more than 915 mm apart on the top and side plating of tunnels.

2 The section modulus of stiffeners is not to be less than that obtained from the following formula. Where the stiffeners are welded to the plating and the end connections are also completely welded, the section modulus may be reduced by 10%.

$$4.4Shl^2 \ \ (cm^3)$$

Where:

l: Distance (m) from the heel of the lower edge of the side wall to the top of the flat side

S: Spacing of stiffeners (m).

h: Vertical distance (m) at mid-length of each hold from the mid-point of l to the bulkhead deck

3 Where the ratio of the radius of the rounded tunnel top to the height of the tunnel is comparatively large, the section modulus of stiffeners is to be adequately increased over that specified in **-2**.

4 Each stiffener is to overlap and to be riveted to the boundary angles, and the lower ends of stiffeners over 150 mm in depth are to be connected to parts such as the inner bottom plating by lug connections.

20.6.8 Construction under Masts, Stanchions, and Other Vertical Pieces

Where vertical pieces such as masts and stanchions are attached atop tunnels or tunnel recesses, local strengthening is to be provided in proportion to the weight carried.

20.6.9 Tunnel Top or Tunnel Recess Top Forming Part of the Deck

Where the top of tunnels or tunnel recesses forms part of the deck; beams, pillars and girders under the top are to be of the scantlings required for similar members of bulkhead recesses.

20.6.10 Ventilators and Escape Trunks

Escape trunks and ventilators provided in tunnels or tunnel recesses are to be made watertight up to the bulkhead deck and are to be strong enough to withstand the pressure to which they may be subjected.

20.6.11 Tunnels in Water or Oil Tanks

Tunnels in water or oil tanks are to be of equivalent construction and strength to those required for deep tank bulkheads.

20.6.12 Watertight Tunnels

Where watertight tunnels similar to shaft tunnels are provided, they are to be of similar construction to the shaft tunnels.

20.6.13 Cylindrical Tunnels

Where cylindrical tunnels pass through deep tanks, the thickness of the plating in way of the tanks is not to be less than that obtained from the following formula:

$$9.1 + 0.134 d_t h \ (mm)$$

Where:

d_t: Diameter of tunnel (m)

h: Greater of the vertical distances given below:

Vertical distance (m) measured from the bottom of tunnel to the mid-point between the top of tanks and the top of overflow pipes

0.7 *times* the vertical distance (m) measured from the bottom of tunnel to the point of 2.0 *metres* above the top of overflow pipes

Chapter 21 BULWARKS, GUARDRAILS, FREEING ARRANGEMENTS, CARGO PORTS AND OTHER SIMILAR OPENINGS, SIDE SCUTTLES, RECTANGULAR WINDOWS, VENTILATORS AND GANGWAYS

21.1 Bulwarks and Guardrails

21.1.1 General

1 Efficient guardrails or bulwarks are to be provided around all exposed decks.

2 Guardrails specified in **-1** above are to comply with the followings:

(1) Fixed, removable or hinged stanchions are to be fitted about 1.5 *m* apart. Removable or hinged stanchions are to be capable of being locked in the upright position.

(2) At least every third stanchion is to be supported by a bracket or stay. Alternatively, measures deemed appropriate by the Society are to be taken.

(3) Where necessary for the normal operation of the ship, steel wire ropes may be accepted in lieu of guardrails. The wires are to be made taut by means of turnbuckles.

(4) Where necessary for the normal operation of the ship, chains fitted between two fixed stanchions and/or bulwarks are acceptable in lieu of guardrails.

21.1.2 Dimensions

1 The height of bulwarks or guardrails specified in **21.1.1** is to be at least 1 *m* from the upper surface of the deck, however, where this height would interfere with the normal operation of the ship and the Society is satisfied that adequate alternative protection is provided; a lesser height may be permitted.

2 Guardrails fitted on superstructure and freeboard decks are to have at least three courses. The clearance below the lowest course of guardrails is not to exceed 230 *mm*, and the other courses are not more than 380 *mm* apart. In other locations, guardrails with at least two courses are to be fitted.

3 For ships with rounded gunwales, the guardrail supports are to be placed on the flat part of the deck.

21.1.3 Construction

1 Bulwarks are to be strongly constructed and effectively stiffened on their upper edges. The thickness of bulwarks on the freeboard deck is generally to be at least 6 *mm*.

2 Bulwarks are to be supported by stiffened stays connected to the deck in way of beams or at effectively stiffened positions. The spacing of these stays on the freeboard deck is not to be more than 1.8 *m*.

3 Bulwarks on the decks which are designed to carry timber deck cargoes are to be supported by specially strong stays spaced not more than 1.5*m* apart.

4 A bracket type is recommended for the lower connections of bulwark stays (*See* **Fig. CS21.1**). In cases where a gusset type is applied for the lower connections of bulwark stays (*See* **Fig. CS21.2**), special consideration is to be given.

5 In cases where a bracket type is applied for the lower connections of bulwark stays, the bulwark stays are to be properly stiffened for the prevention of local buckling.

6 Expansion joints are to be provided at appropriate intervals in bulwarks.

Fig. CS21.1 Example of Bracket Type

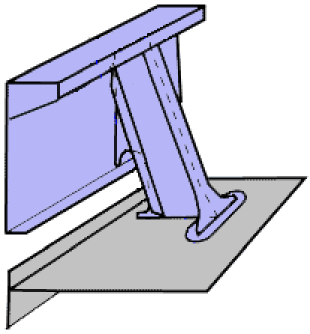
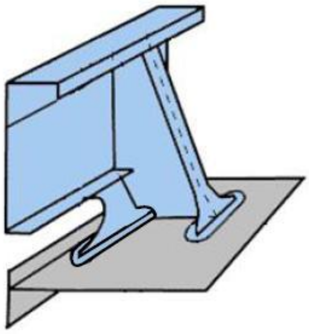


Fig. CS21.2 Example of Gusset Type



21.1.4 Miscellaneous

1 Gangways and other openings in bulwarks are to be well clear of the breaks of superstructures.

2 Where bulwarks are cut to form gangways or other openings, stays of increased strength are to be provided at the ends of the openings.

3 The plating of bulwarks in way of mooring pipes is to be doubled or increased in thickness.

4 At ends of superstructures, the bulwark rails are to be bracketed either to the superstructure end bulkheads or to the stringer plates of the superstructure decks, or other equivalent arrangements are to be made so that an abrupt change of strength may be avoided.

21.2 Freeing Arrangements

21.2.1 General

1 Where bulwarks on the weather parts of freeboard or superstructure deck form wells, ample provision is to be made for rapidly freeing and draining the decks of water.

2 Ample freeing ports are to be provided for clearing any space other than wells, where water is liable to be shipped and to remain.

3 In ships having superstructures which are open at either or both ends, adequate provision for freeing the space within superstructures is to be provided.

4 In ships having a reduced freeboard, guardrails are to be provided for at least a half of the length of the exposed parts of the weather deck or other effective freeing arrangements are to be considered, as required by the Society.

21.2.2 Freeing Port Area

1 The freeing port area on each side of the ship for each well on the freeboard and raised quarter decks is not to be less than that obtained from the following formulae. The area for each well on superstructure decks other than raised quarter deck is not to be less than one-half of that obtained from the formulae.

Where l is not more than 20 m: $0.7 + 0.035\, l + a$ (m^2)

Where l is more than 20 m: $0.07\, l + a$ (m^2)

l : Length of bulwark (m), but need not be taken as greater than 0.7 L_f

a : As obtained from the following formulae.

Where h is more than 1.2 m: $0.04\, l\, (h - 1.2)$ (m^2)

Where h is not more than 1.2 m, but not less than 0.9 m : 0 (m^2)

Where h is less than 0.9 m: -0.04 l (0.9 - h) (m^2)

h : Average height (m) of bulwarks above the deck

2 In ships either without sheer or with less sheer than the standard, the minimum freeing port area obtained from the formulae in **-1** is to be increased by multiplying with the factor obtained from the following formula:

$$1.5 - \frac{S}{2S_0}$$

S : Average of actual sheer (mm)

S_0 : Average of the standard sheer (mm) according to the requirements in **Part V** of the Rules.

3 Where a ship is provided with a trunk or a hatch side coaming which is continuous or substantially continuous between detached superstructures, the area of the freeing port opening is not to be less than that given by **Table CS21.1**.

Table CS21.1 Area of Freeing Ports

Breadth of hatchway or trunk (m)	Area of freeing ports in relation to the total area of bulwark
0.4 B_f or less	0.2
0.75 B_f or more	0.1

Note:

The area of freeing ports at intermediate breadth is to be obtained by linear interpolation

4 Notwithstanding the requirements in **-1**, to **-3**, where deemed necessary by the Society in ships having trunks on the freeboard deck, guardrails are to be provided instead of bulwarks on the freeboard deck in way of trunks for more than half of the length of the trunk.

21.2.3 Arrangement of Freeing Ports

1 Two-thirds of the freeing port area required by **21.2.2** is to be provided in the half of the well near the lowest point of the sheer curve, and the remaining one-third is to be evenly spread along the remaining length of the well.

2 The freeing ports are to have well rounded corners and their lower edges are to be as near the deck as practicable.

21.2.4 Construction of Freeing Ports

1 Where both the length and the height of freeing ports exceed 230 mm respectively, freeing ports are to be protected by rails spaced approximately 230 mm apart.

2 Where shutters are provided on freeing ports, ample clearance is to be provided to prevent jamming. Hinge pins or bearings of the shutters are to be of non-corrodible materials.

3 The shutters referred to in **-2** are not to be provided with securing appliances.

21.3 Bow Doors and Inner Doors

21.3.1 Application

1 These rules give the requirements for the arrangement, strength and securing of bow doors leading to a complete or long forward enclosed superstructure.

2 In this section, two types of visor and side opening doors (hereinafter collectively referred to as “door(s)”) are provided for.

3 Other types of doors in **-2** are to be specially considered in association with applicable requirements of these rules.

21.3.2 Arrangement of Doors and Inner Doors

1 Doors are to be situated above the freeboard deck. A watertight recess in the collision bulkhead and above the deepest waterline fitted for arrangement of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.

2 An inner door is to be fitted. The inner door is to be part of the collision bulkhead. The inner door does not need to be fitted directly above the bulkhead below, provided it is located within the limits specified for the position of the collision bulkhead. Refer to the regulations of **13.1.1**.

3 A vehicle ramp may be arranged as the inner door specified in **-2**, provided that it forms a part of the collision bulkhead and satisfies the requirements for position of the collision bulkhead as stipulated in **13.1.1**. If this is not possible a separate inner weathertight door is to be installed, as far as is practicable within the limits specified for the position of the collision bulkhead.

4 Doors are to be generally weathertight and give effective protection to inner doors.

5 Inner doors forming part of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with sealing supports on the aft side of the doors.

6 Doors, inner doors and ramps are to be arranged so as to preclude the possibility of the door or ramp causing structural damage to the inner door or to the bulkhead when damage to or detachment of the door or ramp occurs. If this is not possible, a separate inner weathertight door is to be installed, as indicated in **13.1.1**.

7 The requirements for inner doors are based on the assumption that vehicle are effectively lashed and secured against movement in the stowed position.

21.3.3 Strength Criteria

1 Scantling of primary members, and securing and supporting devices of doors and inner doors are to be determined to withstand each design loads using the following permissible stresses:

Shearing stress $\tau = 80/K$ (*N/mm*^{2})

Bending stress $\sigma = 120/K$ (*N/mm*^{2})

Equivalent stress $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 150/K$ (*N/mm*^{2})

K: Coefficient corresponding to the kind of steel

e.g. 1.0 for mild steel, the values specified in **1.3.1-2(1)** for high tensile steel

2 The buckling strength of primary members is to be verified as being adequate.

3 For steel to steel bearings in securing and supporting devices, the bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed $0.8\sigma_y$, where σ_y is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure is to be deemed at the discretion of the Society.

4 The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of bolts not carrying support forces is not to exceed:

$125/K$ (*N/mm*^{2})

K: Coefficient corresponding to the material, as specified in **-1**.

21.3.4 Design Loads

1 Doors

(1) The design external pressure P_e, in *kN/m*^{2}, to be considered for the scantling of primary members and securing and supporting devices of doors is not to be less than the pressure below:

$$P_e = 2.75C_H(0.22 + 0.15\tan\alpha)\left(0.4V\sin\beta + 0.6\sqrt{L}\right)^2 \quad (kN/m^2)$$

$C_H = 0.0125L$ (for $L < 80$ *m*)

1.0 (for $L \geq 80$ *m*)

V : Speed of ship, in *knots*, as specified in **2.1.8, Part A** of the Rules.

L : Length of ship, in *m*, as specified in **2.1.2, Part A** of the Rules.

α : Flare angle at the point to be considered.

β : Entry angle at the point to be considered.

(2) The design external forces F_x, F_y and F_z, considered for the scantlings of securing and supporting devices of doors are not to be less than:

$F_x = P_e A_x$ (kN)

$F_y = P_e A_y$ (kN)

$F_z = P_e A_z$ (kN)

A_x: Area, in m^2, of the transverse vertical projection of the door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark is to be excluded.

A_y: Area, in m^2, of the longitudinal vertical projection of the door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark is to be excluded.

A_z: Area, in m^2, of the horizontal projection of the door between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark is to be excluded.

P_e: External pressure, in kN/m^2, as given in **(1)** with angles α and β defined as follows:

α : Flare angle measured at a location on the shell $h_1/2$ above the bottom of the door and $l/2$ aft of the intersection of the door with the stem,

β : Entry angle measured at a location on the shell $h_1/2$ above the bottom of the door and $l/2$ aft of the intersection of the door with the stem,

l : Length, in m, of the door at a height $h_1/2$ above the bottom of the door,

w : Breadth, in m, of the door at a height $h_1/2$ above the bottom of the door,

h_1: Height, in m, of the door between the levels of the door and the upper deck or between the bottom of the door and the top of the door, whichever is the lesser,

For doors, including bulwark, of unusual form or proportions, e.g. ships with a rounded nose and large stem angles, the area and angles used for determination of the design values of external forces may require special consideration.

(3) For visor doors the closing moment M_y under external loads, in kN-m, is to be taken as:

$$M_y = F_x a + 10Wc - F_z b$$

W : Mass of the visor door, in *ton*,

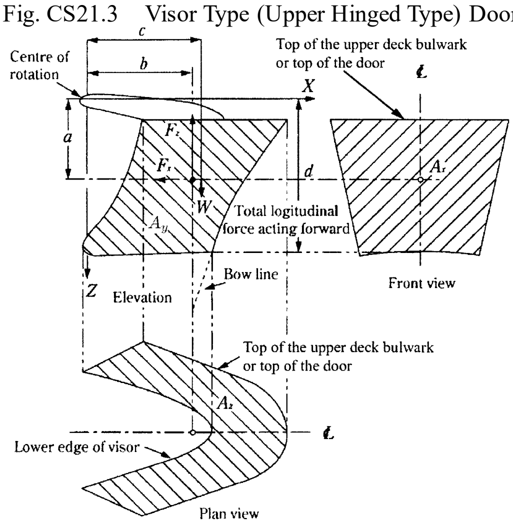
a : Vertical distance, in m, from the visor pivot to the centroid of the transverse vertical projected area of the visor door, as shown in **Fig. CS21.3**

b : Horizontal distance, in m, from the visor pivot to the centroid of the projected area of the visor door, as shown in **Fig. CS21.3**

c : Horizontal distance, in m, from the visor pivot to the centre of gravity of visor mass, as shown in **Fig. CS21.3**

(4) Moreover, the lifting arms of a visor door and its supports are to be dimensioned for the static and dynamic forces applied during lifting and lowering operations, and a minimum wind pressure of 1.5 kN/m^2 is to be taken into account.

Fig. CS21.3 Visor Type (Upper Hinged Type) Door



2 Inner doors

(1) The design external pressure, considered for the scantlings of primary members, securing and supporting devices and surrounding structure of the inner doors is to be taken as the value P_e and P_h, whichever is greater.

$P_e = 0.45L$

hydrostatic pressure $P_h = 10h_2$

h_2 : Distance, in m, from the load point to the top of the cargo space

L : Length as specified in **-1(1)**

(2) The design internal pressure P_b, in kN/m^2, considered for the scantling devices of inner doors is not to be less than the following formula :

$P_b = 25$

21.3.5 Scantlings of Doors

1 General

(1) The strength of the door is to be adequately equivalent to that of the surrounding hull structure.

(2) Adequate strength for opening and closing operations is to be provided in the connections of the lifting arms to the door structure and to the ship structure.

2 Plating

The thickness of door plating is not to be less than that required for the side shell plating or the superstructure side shell plating at the position calculated with the stiffener spacing taken as the frame spacing and it is not to be less than the minimum thickness of the shell plating.

3 Secondary stiffeners

(1) Secondary door stiffeners are to be supported by primary members constituting the main stiffening members of the door.

(2) The section modulus of stiffeners of the door is not to be less than that required for frames at the position calculated with the stiffener spacing taken as the frame spacing. Consideration is to be given to differences in fixity between frames and stiffeners.

(3) Stiffener webs are to have a net sectional area, in cm^2, not less than:

$$A = \frac{QK}{10} \ (cm^2)$$

Q: Shearing force, in kN, in the stiffeners calculated by using uniformly distributed external pressure P_e as given in **21.3.4-1(1)**

K: Coefficient corresponding to the materials as given in **21.3.3-1**

4 Primary structure

(1) The primary members of the door and the hull structure in way are to have sufficient stiffness to ensure integrity of the boundary support of the door.

(2) Scantlings of primary members are generally to be determined by direct strength calculations in association with the external pressure given in **21.3.4-1(1)** and permissible stresses given in **21.3.3-1**. Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections.

21.3.6 Scantlings of Inner Doors

General

(1) The strength of the inner door is to be equivalent to that of the surrounding hull structure.

(2) The thickness of the inner door is not to be less than that required for plating of the collision bulkhead.

(3) Section modulus of stiffeners of the inner door is not to be less than that required for stiffeners of the collision bulkhead.

(4) Scantlings of primary members are generally to be determined by direct calculations in association with the external pressure given in **21.3.4-2(1)** and permissible stresses in **21.3.3-1**. Normally, formulae for the simple beam theory may be applied.

(5) Stiffeners of the inner door are to be supported by girders.

(6) Where inner doors also serve as vehicle ramps, the scantlings are not to be less than those required for vehicle decks.

(7) The distribution of forces acting on the securing and supporting devices is generally to be determined by direct calculations taking into account the flexibility of the structure and the actual position and stiffness of the supports.

21.3.7 Securing and Supporting of Doors

1 General

(1) Doors are to be fitting with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.

(2) The supporting hull structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

(3) Where packing is required, the packing materials is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered.

(4) Maximum design clearance between securing and supporting devices is not generally to exceed 3 mm.

(5) A means is to be provided for mechanically fastening the door and inner door in the open position.

(6) Only active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on these devices. Small and/or flexible devices such as cleats intended to provide local compression of packing material are not generally to be included in the calculations called for in **-2(5)**.

(7) The number of securing and supporting devices are to be the minimum practical whilst taking into account the requirements for redundant provisions given in **-2(6)**, **-2(7)** and the available space for adequate support in the hull structure. Securing devices and supporting devices are to be provided at intervals not exceeding 2.5 m and as close to each corner of the door as is practicable.

(8) For visor doors that open outwards, the pivot arrangement is generally to be such that the visor is self closing under external loads, that is $M_y > 0$. Moreover, the closing moment M_y as given in **21.3.4-1(3)** is to be not less than M_{y0} :

$$M_{y0} = 10Wc + 0.1\sqrt{a^2 + b^2}\sqrt{F_x^2 + F_z^2} \quad (kN\text{-}m)$$

W, a, b, c, F_x and F_z: As specified in **21.3.4-1**

2 Scantlings

(1) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in **21.3.3-1**.

(2) For visor doors, the reaction forces applied on the effective securing and supporting devices, assuming the door as a rigid body, are determined for the following combination of external loads acting simultaneously with the self weight of the door:

(a) Case 1: F_x and F_z

(b) Case 2: $0.7F_y$ acting on each side separately together with $0.7F_x$ and $0.7F_z$

Where F_x, F_y and F_z are determined as indicated in **21.3.4-1(2)** and applied at the centroid of projected areas.

(3) For side-opening doors, the reaction forces applied on the effective securing and supporting devices, assuming the door as a rigid body, are determined for the following combination of external loads acting simultaneously with the self weight of the door:

(a) Case 1: F_x, F_y and F_z acting on both doors

(b) Case 2: $0.7F_x$ and $0.7F_z$ acting on both doors and $0.7F_y$ acting on each door separately,

Where F_x, F_y and F_z are determined as indicated in **21.3.4-1(2)** and applied at the centroid of projected areas.

(4) The support forces as determined according to **(2)(a)** and **(3)(a)** shall generally give rise to a zero moment about the transverse axis through the centroid of the area A_x. For visor doors, longitudinal reaction forces of pin and/on or wedge supports to the door base contributing to this moment are not to be of the forward direction.

(5) The distribution of the reaction forces acting on the securing and supporting devices may require to be determined by direct calculations taking into account the flexibility of the hull structure and the actual position and stiffness of the supports.

(6) The arrangement of securing and supporting devices is to be designed with redundancy so that in the event of failure of any single securing of supporting device the remaining devices are capable of withstanding the reaction forces without exceeding by more than 20% of the permissible stresses as given in **21.3.3-1**.

(7) For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the permissible stresses given in **21.3.3-1**. The opening moment M_0, in *kN-m*, to be balanced by this reaction force, is not to be taken as less than :

$M_0 = 10Wd + 5A_x a$

d : Vertical distance, in m, from the hinge axis to the centre of the door

W, A_x, a : As defined in **21.3.4-1**

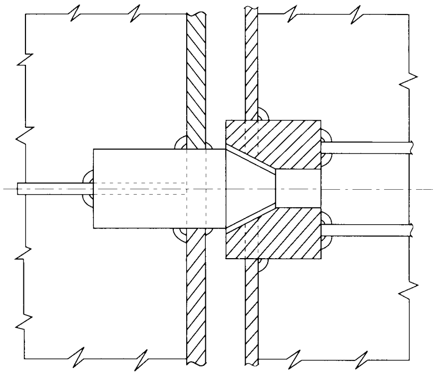
(8) For visor doors, the securing and supporting devices excluding the hinges should be capable of resisting the vertical design forces $(F_z - 10W)$ within the permissible stresses given in **21.3.3-1**.

(9) All load transmitting elements in the design load path, from door through securing and supporting devices into the ship structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices.

(10) For side-opening doors, the thrust bearing has to be provided in way of girder ends at the closing of the two leaves to prevent one leaf from shifting towards the other one under the effect of unsymmetrical pressure (*See* example of **Fig. CS21.4**). Each part of the thrust bearing has to be kept secured on the other part by means of securing devices.

(11) Notwithstanding the provision in **(10)**, any other arrangement serving the same purpose may be proposed.

Fig. CS21.4 Example of Thrust Bearing



21.3.8 Securing and Locking Arrangement

1 System for operation

(1) Securing devices are to be simple to operate and easily accessible.

(2) Securing devices are to be equipped with a mechanical locking arrangement (self locking or separate arrangement), or to be of the gravity type.

(3) The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(4) Doors and inner doors giving access to vehicle decks are to be provided with an arrangement for remote control of the following from a position above the freeboard deck:

(a) Closing and opening the doors

(b) Associated securing and locking of every door.

(5) Indication of the open/closed position of every door and every securing and locking devices are to be provided at the remote control, stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be supplemented by warning indicator lights is to be displayed.

(6) Where hydraulic securing devices are used, the system is to keep the door mechanically closed and locked even in the event of loss of hydraulic fluid. The hydraulic system for securing and locking devices is to be isolated from other circuits, when in the closed position.

2 System for indication/monitoring

(1) Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the door and inner door are closed that their securing and locking devices are properly positioned. The indication panel is to be provided with a lamp test function. In addition, the turning off of the indicator light is not to be possible.

(2) The indicator system is to be designed on fail safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if the securing devices become open or the locking devices become unsecured. The power supply for the indicator system is to be independent of the power supply for operating and closing the doors. The sensor of the indicator system is to be protected from water, ice formation and mechanical damage.

(3) The indication panel on the navigation bridge is to be equipped with mode a section function "harbour/sea voyage", so arranged that an audible alarm is given if vessel leaves the harbor with its door or inner door not closed and not closed any of the securing devices not in the correct position.

(4) A water leakage detection system with audible alarm and television surveillance is to be arranged to provide indication to the navigation bridge and to he engine control room of leakage through the inner door.

(5) A television surveillance system is to be fitted between the door and inner door with a monitor on the navigation bridge and in the engine control room. The system must monitor the position of the doors and a sufficient number of their securing devices. Special consideration is to be given for lighting and contrasting colour of objects under surveillance.

(6) A drainage system is to be arranged in the area between the door and ramp, or where no ramp is fitted, between the door and inner door. The system is to be equipped with an audible alarm function at the navigation bridge which is set off when the water levels in these areas exceeds 0.5 *m* or the high water level alarm, whichever is lesser.

21.3.9 Reinforcement around Door Openings

1 Shell plating is to be properly rounded at the corners of door openings and is to be reinforced by thicker plate or by doubling plate around the openings.

2 Where frames are cut at the door opening, web frames are to be fitted on both sides of the opening and the structure is to be such that it properly supports beams above the opening.

21.3.10 Operating and Maintenance Manual

1 An operating and maintenance manual for the door and inner door which is approved by the Society has to be provided on board and contain information on:

(1) Main particulars and design drawings
  (a) Special safety precautions
  (b) Details of vessel
  (c) Equipment and design loading (for ramps)
  (d) Key plan of equipment (doors, inner bow doors and ramps)
  (e) Manufacturer's recommended testing for equipment
  (f) Description of equipment
    i) Doors
    ii) Inner bow doors
    iii) Bow ramp
    iv) Central power pack
    v) Bridge panel
    vi) Engine control room panel

(2) Service conditions
  (a) Limiting heel and trim of ship for loading/unloading
  (b) Limiting heel and trim for door/inner bow door operations
  (c) Doors / Inner bow doors / Ramps operating instructions
  (d) Doors / Inner bow doors/ Ramps emergency operating instructions

(3) Maintenance
  (a) Schedule and extent of maintenance
  (b) Trouble shooting and acceptable clearances

(c) Manufacturer's maintenance procedures

(4) Register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

2 Documented operating procedures for closing and securing the door and inner door are to be kept on board and posted at the appropriate place.

21.4 Side Shell Doors and Stern Doors

21.4.1 Application

These rules give the requirements for the arrangement, strength and securing of side shell doors, abaft the collision bulkhead, and stern doors (hereinafter collectively referred to as "door(s)") leading into enclosed spaces.

21.4.2 Arrangement of Doors

1 Doors are to be made weathertight.

2 Where the lower edges of any openings of the doors are situated below the freeboard deck, the doors are to be so designed as to ensure the same watertightness and structural integrity as the surrounding shell plating.

3 Notwithstanding the requirements in **-2**, the lower edges of the doors are not to be below a line drawn parallel to the freeboard deck at side, which has at its lowest point at least 230 *mm* above the deepest subdivision draught specified in **4.1.2(3)**, unless the implementation of additional measures for ensuring watertightness such as the following **(1)** to **(4)**.

(1) A second door of equivalent strength and watertightness is to be fitted inside the watertight door

(2) A leakage detection device is provided in the compartment between the two doors

(3) Drainage of this compartment to the bilges is controlled by a readily accessible screw-down valve

(4) The outer door opens outwards

4 The number of door openings is to be kept to the minimum compatible with design and proper operation of the ship.

5 Doors are generally to open outwards.

21.4.3 Strength Criteria

1 Scantlings of primary members and securing and supporting devices of doors are to be determined to withstand the design loads defined in **21.4.4**, using the following permissible stresses:

shear stress : $\tau = \dfrac{80}{K}$ (N/mm^2)

bending stress : $\sigma = \dfrac{120}{K}$ (N/mm^2)

equivalent stress : $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = \dfrac{150}{K}$ (N/mm^2)

K: Coefficient corresponding to the kind of steel

e.g. 1.0 for mild steel, the values specified in **1.3.1-2(1)** for high tensile steel

2 The buckling strength of primary members is to be verified as being adequate.

3 For steel to steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed $0.8\sigma_Y$, where σ_Y is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure is to be deemed at the discretion of the Society.

4 The arrangements of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of threads bolts not carrying support forces is not to exceed:

$125/K$ (N/mm^2)

K: Coefficient corresponding to the material, as specified in **-1**.

21.4.4 Design Loads

The design loads for primary members are securing and supporting devices are not to be less than the values given by **Table CS21.2** respectively.

Table CS21.2 Design Loads

		F_e (kN) (External force)	F_i (kN) (Internal force)
Securing and supporting devices	Door opening inwards	AP_e+F_p	$F_0+10\ W$
	Door opening outwards	AP_e	$F_0+10\ W+F_p$
Primary members[1)]		AP_e	$F_0+10\ W$

Notes:

1) Design loads for primary members is F_e or F_i, whichever is the greater.

A : Area, in m^2, of the door that bears the actual load in the loading direction.

W : Mass of the door, in *tons*

F_p : Total packing force, in kN. Packing line pressure is normally not to be taken as less than 5 N/mm.

F_0 : The greater of F_c and $5A$ (kN)

F_c : Accidental force, in kN, due to loose cargo etc., to be uniformly distributed over the area A and not to be taken as less than 300 kN. Where the area of doors is less than 30 m^2, the valve of F_c may be appropriately reduced to $10\ A$ (kN). However, the valve of F_c may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.

P_e : External design pressure, in kN/m^2, determined at the center of gravity of the door opening and not to be taken as less than the value specified in **Table CS21.3**

Table CS21.3 External Design Pressure P_e

	$P_e (kN/m^2)$
$ZG < T$	$10(T - ZG) + 25$
$ZG \geq T$	25

Notes:

For stern doors of ships fitted with bow doors, P_e is not to be taken as less than:

$P_e = 0.6C_H\left(0.8 + 0.6\sqrt{L}\right)^2$

T: Deepest subdivision draught defined in **4.1.2(3)**, in m.

ZG: Height of the center of area of the door, in m, above the baseline.

C_H: Coefficient given as follow;

where $L <$ 80 m: 0.0125 L

where $L \geq$ 80 m: 1

L: Length of ship, in m, as specified in **2.1.2, Part A** of the Rules.

21.4.5 Scantlings of Doors

1 General

(1) The strength of doors is to be commensurate with that of the surrounding structure.

(2) Doors are to be adequately stiffened and means are to be provided to prevent any lateral or vertical movement of the doors when closed.

(3) Adequate strength is to be provided in the connections of the lifting/manoeuvring arms and hinges to the door structure and to the ship's structure.

(4) Where doors also serve as vehicle ramps, the design of the hinges should take into account the ship angle of trim and heel which may result in uneven loading on the hinges.

2 Plating

(1) The thickness of door plating is not to be less than the required thickness for the side shell plating or the superstructure side shell plating using the door stiffener spacing, but the thickness of the stern door which is not exposed to direct wave impact by a permanent ramp way provided outside the stern door may be reduced by 20 % from the required thickness prescribed above.

(2) Notwithstanding the provision in **(1)** above, the thickness of the door plating is not to be less than the minimum required thickness of shell plating.

(3) Where the doors serve as vehicle ramps, the plating thickness is not to be less than that required for vehicle decks.

3 Secondary stiffeners

(1) The secondary stiffeners are to be supported by primary members constituting the main stiffening of the door.

(2) The section modulus of horizontal or vertical stiffeners is not to be less than that required for frames in the position calculated with the stiffener spacing taken as the frame spacing. Consideration is to be given, where necessary, to differences in fixity between the ship's frames and the door stiffeners.

(3) Where doors serve as vehicle ramps, the stiffeners scantlings are not to be less than that required for vehicle decks.

4 Primary structure

(1) Scantlings of primary members are generally to be determined by direct strength calculations in association with the design loads given in **21.4.4** and permissible stresses given in **21.4.3-1**. Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections.

(2) Webs of primary members are to be properly stiffened in the vertical direction to shell plating.

(3) The primary members and the hull structure in way are to have sufficient stiffness to ensure structural integrity of the boundary of the doors.

(4) Ends of stiffeners and primary members of the doors are to have sufficient rigidity against rotation and the moment of inertia is not to be less than that obtained from the following formula:

$$8d^4F_p \ (cm^4)$$

Where:

d : Distance between securing device (m)

F_p : See Notes for **Table CS21.2**.

(5) Moment of inertia of boundary members of the door which support primary members between securing devices is to be increased in proportion to force.

21.4.6 Securing and Supporting of Doors

1 General

(1) Doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.

(2) The supporting hull structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

(3) Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be as considered appropriate by the Society.

(4) Maximum design clearance between securing and supporting devices is not generally to exceed 3 mm.

(5) A means is to be provided for mechanically fastening the door in the open position.

(6) Only active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on these devices. Small and/or flexible devices such as cleats intended to provide local compression of the packing material are not generally to be included in the calculations called for in **-2(2)** above.

(7) The number of securing and supporting devices are generally to be the minimum practical whilst taking into account the requirement for redundant provision given in **-2(3)** and the available space for adequate support in the hull structure. Securing devices and supporting devices are to be provided at intervals not exceeding 2.5 m and as close to each corner of the door as is practicable.

2 Scantlings

(1) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in **21.4.3-1**.

(2) The distribution of the reaction forces acting on the securing devices and supporting devices may require to be determined by direct calculations taking into account the flexibility of the hull structure and the actual position of the supports.

(3) The arrangement of securing devices and supporting devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable of withstanding the reaction forces without exceeding by more than 20 % of the permissible stresses given in **21.4.3-1**.

(4) All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's

structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices.

21.4.7 Securing and Locking Arrangement

1 Systems for operation

(1) Securing devices are to be simple to operate and easily accessible.

(2) Securing devices are to be equipped with a mechanical locking arrangement (self locking or separate arrangement), or are to be of the gravity type.

(3) The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(4) Doors which are located partly or totally below the freeboard deck with a clear opening area greater than 6 m^2 are to be provided with an arrangement for remote control of the following from a position above the freeboard deck:

(a) Closing and opening of the doors

(b) Associated securing and locking of every door

(5) For doors which are required to be equipped with a remote control arrangement, indication of the open/closed position of the door and the securing and locking device is to be provided at the remote control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

(6) Where hydraulic securing devices are used, the system is to keep the door mechanically closed and locked even in the event of loss of hydraulic fluid. The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in the closed position.

2 Systems for indication/monitoring

(1) The following requirements apply to doors in the boundary of special category spaces or Ro-Ro spaces through which such spaces may be flooded. For cargo ships, where no part of the door is below the uppermost waterline and the area of the door opening is not greater than 6 m^2, then the requirements of this section need not be applied.

(2) Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each operating panel to indicate that the doors are closed and that their securing and locking devices are properly positioned. The indication panel is to be provided with a lamp test function. In addition, the turning off of the indicator light is not to be possible.

(3) The indicator system is to be designed on the fail safe principle and is to indicate by visual alarms if the door is not fully closed and not fully locked and by audible alarms if the securing devices become open or the locking devices become unsecured. The power supply for the indicator system is to be independent of the power supply for operating and closing the doors and is to be provided with a backup power supply. The sensors of the indicator system are to be protected from water, ice formation and mechanical damage.

(4) The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that an audible alarm is given if the vessel leaves the harbour with its side shell or stern doors not closed or with any of the securing devices not in the correct position.

(5) For passenger ships, a water leakage detection system with an audible alarm and television surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of any leakage through the doors.

(6) For cargo ships, a water leakage detection system with an audible alarm is to be arranged to provide an indication to the navigation bridge of any leakage through the doors.

21.4.8 Reinforcement around Door Openings

1 Shell plating is to be properly rounded at the corners of door openings and is to be reinforced by thicker plate or by doubling plate around the openings.

2 Where frames are cut at door openings, adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

21.4.9 Operating and Maintenance Manual

1 An approved Operating and Maintenance Manual for the doors is to be provided on board and contain necessary information on:

(1) Main particulars and design drawings
  (a) Special safety precautions
  (b) Details of vessel
  (c) Equipment and design loading (for ramps)
  (d) Key plan of equipment (doors and ramps)
  (e) Manufacturer's recommended testing for equipment
  (f) Description of equipment
    i) Side doors
    ii) Stern doors
    iii) Central power pack
    iv) Bridge panel
    v) Engine control room panel
(2) Service conditions
  (a) Limiting heel and trim of ship for loading/unloading
  (b) Limiting heel and trim for door operations
  (c) Doors/Ramps operating instructions
  (d) Doors/Ramps emergency operating instructions
(3) Maintenance
  (a) Schedule and extent of maintenance
  (b) Trouble shooting and acceptable clearances
  (c) Manufacturer's maintenance procedures
(4) Register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

2 Documented operating procedures for closing and securing doors are to be kept on board and posted at the appropriate places.

21.5 Side Scuttles and Rectangular Windows

21.5.1 General Application

1 The requirements in this chapter apply to side scuttles and rectangular windows on the side shell, superstructures and deckhouses up to the third tier above the freeboard deck. The requirements for the deckhouses, superstructures and side shell above the third tier are to be as deemed appropriate by the Society.

2 Notwithstanding **-1** above, windows on the deckhouse up to the third tier above the freeboard deck may be as deemed appropriate by the Society for windows that do not interfere with the watertightness of the ship and are deemed as necessary for the ship's operation such as those on the navigation bridge.

21.5.2 General Requirement for Position of Side Scuttles

1 No side scuttle is to be provided where its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point 2.5% of the breadth of the ship (B') specified in **4.1.2(11)** or 500 mm, whichever is greater, above the deepest subdivision draught specified in **4.1.2(3)**. Side scuttles that have their sill below the freeboard deck and which are of a hinged type are to be provided with locking arrangements.

2 No side scuttle is to be provided at any space solely engaged in the carriage of cargoes.

3 The deadlights of side scuttles deemed appropriate by Society may be portable, provided that such scuttles comply with the following requirements **(1)** to **(4)**:

(1) Fitting class *A* side scuttles or class *B* side scuttles is not required.
(2) Such side scuttles are fitted abaft one eighth of the length for freeboard from the forward perpendicular.
(3) Such side scuttles are fitted above a line drawn parallel to the bulkhead deck at side and having its lowest point at a height of 3.7 m plus 2.5% of the breadth of the ship (B') specified in **4.1.2(11)** above the deepest subdivision draught specified in **4.1.2(3)**.
(4) Such portable deadlights are to be stowed adjacent to the side scuttles they serve.

4 Automatic ventilating side scuttles is not to be fitted in the shell plating below the freeboard deck.

21.5.3 Application of Side Scuttles

1 Side scuttles inboard are to be class *A* side scuttles, class *B* side scuttles, or class *C* side scuttles complying with the requirements in **Chapter 7**, **Part L** or equivalent thereto.

2 Class *A* side scuttles, class *B* side scuttles and class *C* side scuttles are to be so arranged that their design pressure is less than the maximum allowable pressure determined by their nominal diameters and grades. (See **21.5.5**)

3 Side scuttles to spaces below the freeboard deck and those provided to sunken poops are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.

4 Side scuttles exposed to direct impact from waves, or that are to spaces within the first tier of side shell or superstructures, first tier deckhouses on the freeboard deck which have unprotected deck openings leading to spaces below the freeboard deck inside, or deckhouses considered buoyant in stability calculations, are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.

5 Where an opening in the superstructure deck or in the top of the deckhouse on the freeboard deck which gives access to a space below the freeboard deck or to a space within an enclosed superstructure is protected by the deckhouse or companion, the side scuttles fitted to those spaces which give direct access to an open stairway are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto. Where cabin bulkhead or door separate side scuttles from a direct access leading below the freeboard deck, application of side scuttles is to be as deemed appropriate by the Society.

6 Side scuttles to the spaces in the second tier on the freeboard deck considered buoyant in stability calculations are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.

7 In ships with an unusually reduced freeboard, side scuttles located below the waterline after flooding into compartments are to be of a fixed type.

21.5.4 Protection of Side Scuttles

All side scuttles in way of the anchor housing and other similar places where they are liable to be damaged are to be protected by strong gratings.

21.5.5 Design Pressure and Maximum Allowable Pressure of Side Scuttles

1 The design pressure of side scuttles is to be less than the maximum allowable pressure (See **Table CS21.4**) determined by their nominal diameters and grades. The design pressure *P* is to be determined using the following equation.

$P = 10ac(0.067bL - y)$ (kPa)

a, c and b: As specified in **18.2.1-1.**

y: Vertical distance (m) from side scuttle sill to summer load line (or timber load line if given).

2 Notwithstanding the provision of **-1** above, the design pressure is not to be less than the minimum design pressure given in **Table CS21.5**.

21.5.6 General Requirement for Position of Rectangular Windows

No rectangular window is to be provided to spaces below the freeboard deck, the first tier of superstructures, and the first tier of deckhouses considered buoyant in stability calculations or which protect deck openings leading to spaces below the freeboard deck inside.

Table CS21.4 Maximum Allowable Pressure of Side Scuttles

Class	Nominal diameter (*mm*)	Glass thickness (*mm*)	Maximum allowable pressure (*kPa*)
A	200	10	328
	250	12	302
	300	15	328
	350	15	241
	400	19	297
B	200	8	210
	250	8	134
	300	10	146
	350	12	154
	400	12	118
	450	15	146
C	200	6	118
	250	6	75
	300	8	93
	350	8	68
	400	10	82
	450	10	65

Table CS21.5 Minimum Design Pressure

	$L \leq 50\ m$	$50\ m < L < 90\ m$
Exposed front bulkhead of the first tier superstructure	30 (*kPa*)	$25 + L/10$ (*kPa*)
Other places	15 (*kPa*)	$12.5 + L/20$ (*kPa*)

21.5.7 Application to Rectangular Windows

1 Rectangular windows inboard are to be class *E* rectangular windows and class *F* rectangular windows complying with the requirements in **Chapter 8**, **Part L** or equivalent thereto.

2 Class *E* rectangular windows and class *F* rectangular windows are to be so arranged that the design pressure is less than the maximum allowable pressure determined by their nominal size and grade. (See **21.5.8**)

3 Rectangular windows to spaces in the second tier of the freeboard deck which gives direct access to a spaces within the first tier of enclosed superstructures or below the freeboard deck are to be provided with hinged deadlights or externally fixed shutters. Where cabin bulkheads or doors separate the space within the second tier from spaces below the freeboard deck or spaces within the first tier of enclosed superstructures, application of rectangular windows to the spaces within the second tier is to be as deemed appropriate by the Society.

4 Rectangular windows to spaces in the second tier of the freeboard deck considered buoyant in stability calculations are to be provided with hinged deadlights or externally fixed shutters.

21.5.8 Design Pressure and Maximum Allowable Pressure of Rectangular Windows

1 The design pressure of rectangular windows is to be less than the maximum allowable pressure (See **Table CS21.6**) determined by their grades and nominal diameters. The design pressure *P* is to be determined using the following equation.

$P = 10ac(0.067bL - y)$ (*kPa*)

a, c and b: As specified in **18.2.1-1.**

y: Vertical distance (*m*) from the sill of rectangular window to summer load line (or timber load line if given).

2 Notwithstanding the provision of **-1** above, the design pressure is not to be less than the minimum design pressure as given in **Table CS21.5**.

Table CS21.6 Maximum Allowable Pressure of Rectangular Windows

Class	Nominal size width(*mm*)×height(*mm*)	Glass thickness (*mm*)	Maximum allowable pressure (*kPa*)
E	300×425	10	99
	355×500	10	71
	400×560	12	80
	450×630	12	63
	500×710	15	80
	560×800	15	64
	900×630	19	81
	1000×710	19	64
F	300×425	8	63
	355×500	8	45
	400×560	8	36
	450×630	8	28
	500×710	10	36
	560×800	10	28
	900×630	12	32
	1000×710	12	25
	1100×800	15	31

21.6 Ventilators

21.6.1 Height of Ventilator Coamings

The height of ventilator coamings above the upper surface of the deck is to be at least 900 *mm* in Position I and 760 *mm* in Position II as specified in **19.1.2**. Where the ship has an unusually large freeboard or where the ventilator serves spaces within unenclosed superstructures, the height of ventilator coamings may be suitably reduced.

21.6.2 Thickness of Ventilator Coamings

1 The thickness of ventilator coamings in Positions I and II specified in **19.1.2** leading to spaces below the freeboard deck or within enclosed superstructures is not to be less than that given by Line 1 in **Table CS21.7**. Where the height of the coamings is reduced by the provisions in **21.6.1**, the thickness may be suitably reduced.

2 Where ventilators pass through superstructures other than enclosed superstructures, the thickness of ventilator coamings in the superstructures is not to be less than that given by Line 2 in **Table CS21.7**

Table CS21.7 Thickness of Ventilation Coaming

Inside diameter of ventilator (*mm*)	Above Not exceeding	70	70 100	100 130	130 160	160 190	190
Thickness of coaming plate (*mm*)	Line 1	6.3	7.1	8.0	8.8	8.8	8.8
	Line 2	4.5	4.5	4.5	4.5	5.4	6.3

21.6.3 Connection

Ventilator coamings are to be efficiently connected to the deck and where their height exceeds 900 *mm* are to be specially supported.

21.6.4 Cowls

Ventilator cowls are to be fitted closely to coamings and are to have housings of not less than 380 *mm*, except that a smaller housing may be permitted for ventilators of not greater than 200 *mm* in diameter.

21.6.5 Closing Appliances

1 Ventilators to machinery and cargo spaces are to be provided with a means for closing the openings that is capable of being operated from outside the spaces in case of fire. Furthermore, these ventilators are to be provided with an indicator that enables confirmation whether the shutoff is open or closed from outside of the ventilator as well as suitable means of inspection for closing appliances.

2 All ventilator openings in exposed positions on the freeboard and superstructure decks are to be provided with efficient weathertight closing appliances. Where the coaming of any ventilator extends to more than 4.5 *m* above the surface of the deck in Position I or more than 2.3 *m* above the surface of the deck in Position II specified in **19.1.2**, such closing appliances may be omitted unless required in **-1**.

21.6.6 Ventilators for Deckhouses

The ventilators for the deckhouses which protect the companionways leading to the spaces below the freeboard deck are to be equivalent to those for the enclosed superstructures.

21.6.7 Ventilators for Emergency Generator Room

The coamings of ventilators supplying the emergency generator room is to extend to more than 4.5 *m* above the surface of the deck in Position I, and more than 2.3 *m* above the surface of the deck in Position II specified in **19.1.2**. The ventilator openings are not to be fitted with weathertight closing appliances, except for those complying with **1.3.5-2, Part D**. However, where due to vessel size and arrangement this requirement is not practicable, the height of ventilator coamings is to be at the discretion of the Society.

21.6.8 Additional Requirement for Ventilators Fitted on Exposed Fore Deck

1 For ships of 80 *m* or more in length L_1, the ventilators located on the exposed deck forward of 0.25 L_1 are to be of sufficient strength to resist green sea force if the height of the exposed deck in way of those ventilators is less than 0.1 L_1 or 22 *m* above the designed maximum load line, whichever is smaller. The length L_1 is the distance (*m*) measured on the waterline at the scantling draught d_S from the forward side of the stem to the centre of the rudder stock. L_1 is to be not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught d_S. In ships without rudder stocks (e.g. ships fitted with azimuth thrusters), the Rule length L_1 is to be taken equal to 97% of the extreme length on the waterline at the scantling draught d_S. d_S is the scantling draught (*m*) at which the strength requirements for the scantlings of the ship are met and represents the full load condition; it is to be not less than that corresponding to the assigned freeboard.

2 This requirement does not apply to the cargo tank venting systems and inert gas systems of tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk.

21.7 Gangways

21.7.1 General

Satisfactory means (in the form of guardrails, life lines, gangways or under deck passages, etc.) are to be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the ship.

21.7.2 Tankers

1 The requirements in **21.7.2** apply to tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk (hereinafter referred to as "tankers") engaged in international voyages and of not less than 24 *m* in freeboard length (L_f).

2 Tankers are to be provided with the means to enable crew to gain safe access to their bow even in severe weather conditions.

21.8 Means of Embarkation and Disembarkation

21.8.1 General

Ships of not less than 500 *gross tonnage* are to be provided with appropriate means of embarkation on and disembarkation from ships for use in port and in port related operations, unless specially approved by the Society.

Chapter 22 CEILINGS, SPARRINGS, CEMENTING AND PAINTING

22.1 Ceilings

22.1.1 Ships with Single Bottoms

1 In ships with single bottoms, close ceilings are to be provided on the floors up to the upper turn of the bilge.

2 The thickness of ceilings is not to be less than: 50 *mm* for ships under 61 *metres* in length; 57 *mm* for ships between 61 *metres* and 76 *metres* in length; 63 *mm* for ships greater than 76 *metres* in length.

3 The ceilings on the flat on the floors are to be laid in portable sections, or other convenient arrangements are to be made for easy removal where required for cleaning, painting or inspection of the bottom.

22.1.2 Ships with Double Bottoms

1 In ships with double bottoms, close ceilings are to be laid from the margin plate to the upper turn of the bilge so arranged as to be readily removable for inspection of the limbers.

2 Ceilings are to be laid on the inner bottoms under hatchways, unless the requirements in **6.7.1** are applied.

3 Ceilings on the top of double bottoms are to be laid on battens not less than 13 *mm* in thickness, or to be bedded on the covering required in **22.3.4**.

4 The thickness of ceilings referred to in **-1** and **-2** is to be as required in **22.1.1-2**.

22.2 Sparrings

22.2.1 Sparrings

1 In all cargo spaces where it is intended to carry general cargo, sparrings not less than 50 *mm* in thickness and not less than 150 *mm* in breadth are to be provided not more than 230 *mm* apart above the bilge ceiling, or equivalent arrangements are to be provided for the protection of framing.

2 In ships intended to carry timbers, hold frames are to be specially protected. However, where it is obvious that the ship is not engaged in the carriage of log cargoes, the protection may be modified.

3 Sparring may be omitted in cargo holds of ships such as coal carriers, bulk carriers, ore carriers and similar ships.

4 General cargo ships may omit sparring only subject to the approval by the Society at the request of owner, in which case the ship is distinguished with the notation "*n.s.*" in the Register Book.

22.3 Cementing

22.3.1 General

The bottom in ships with single bottoms, the bilges in all ships and the double bottoms in the boiler spaces of all ships are to be efficiently protected by Portland cement or other equivalent materials which cover the plates and frames as far as the upper turn of the bilge. However, cement protection may be dispensed with in the bottom of spaces solely used for the carriage of oil.

22.3.2 Portland Cement

Portland cement is to be mixed with fresh water and sand or other satisfactory substances, in the proportion of about one part of cement to two of sand.

22.3.3 Thickness of Cement

The thickness of cement is not to be less than 20 *mm* at the edges.

22.3.4 Special Consideration for Tank Top Plating

The top plating of tanks, where ceiled directly, is to be covered with good tar put on hot and well sprinkled with cement powder, or with other equally effective coatings.

22.4 Painting

22.4.1 General

1 All steelworks are to be coated with a suitable paint. Special requirements may be additionally made by the Society in accordance with the kind of ship, purpose of spaces, etc. However, where it is recognized by the Society that the spaces are effectively protected against the corrosion of steel works by means other than painting or due to the properties of the cargoes, etc., painting may be omitted.

2 Steelworks in tanks intended for water may be coated with wash cement in lieu of paint.

3 The surface of steelworks is to be thoroughly cleaned and loose rust, oil and other harmful adhesives are to be removed before being painted. At least the outer surface of shell plating below the load line is to be sufficiently free from rust and mill scale before painting.

22.4.2 Protective Coatings in Dedicated Seawater Ballast Tanks and Double-side Skin Spaces

For dedicated seawater ballast tanks of all type of ships of not less than 500 *gross tonnage* engaged on international voyages, the requirements are to be complied with *"PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR DEDICATED SEAWATER BALLAST TANKS IN ALL TYPE OF SHIPS AND DOUBLE-SIDE SKIN SPACES OF BULK CARRIERS"* (*IMO Performance Standard for Protective Coatings for Seawater Ballast Tanks, etc. / IMO* resolution *MEPC*.215(82) as may be amended).

22.4.3 Corrosion Protection for Cargo Oil Tanks

Corrosion protection in accordance with the following **(1)** or **(2)** is to be applied to the cargo oil tanks of crude oil tankers of not less than 5,000 *tonnes* deadweight engaged on international voyages:

(1) Coatings in accordance with the *"PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR CARGO OIL TANKS OF CRUDE OIL TANKERS"* (*IMO Performance Standard for Protective Coatings for Cargo Oil Tanks / IMO* resolution *MSC*.288(87) as may be amended); or

(2) Alternative means in accordance with the *"PERFORMANCE STANDARD FOR ALTERNATIVE MEANS OF CORROSION PROTECTION FOR CARGO OIL TANKS OF CRUDE OIL TANKERS"* (*IMO Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks / IMO* resolution *MSC*.289(87) as may be amended).

Chapter 23 EQUIPMENT

23.1 Anchors and Chain Cables

23.1.1 General

1 All ships are to be provided with anchors and chain cables which are not less than that given in **Table CS23.1** according to their equipment number. All ships are to be provided with suitable appliances for handling anchors and ropes.

2 Anchors, chain cables, ropes, etc. for ships with having equipment numbers of 50 or less (EN≤50) are to be determined by the Society.

3 The anchors given in **Table CS23.1** are to be connected to their cables and be positioned on board ready for use.

4 Anchors and chain cables are to comply with the requirements in **Chapter 2** as well as **3.1** in **Chapter 3, Part L of the Rules**.

5 The anchoring equipment subject to the requirements specified in this chapter is based on the following conditions of intended use. The Society may, however, require special consideration be given to anchoring equipment intended for use in deep and unsheltered waters.

(1) The anchoring equipment required herewith is intended for temporary mooring of a ship within a harbour or sheltered area when the ship is awaiting berth, tide, etc. The equipment is, therefore, not designed to hold a ship off fully exposed coasts in rough weather or to stop a ship which is moving or drifting.

(2) The anchoring equipment required herewith is designed to hold a ship in good holding ground conditions so as to avoid dragging of the anchor. In poor holding ground conditions, the holding power of the anchors is significantly reduced.

(3) Anchoring equipment is used under the environmental condition that an assumed maximum current speed of 2.5 *m/s*, a maximum wind speed of 25 *m/s* and a minimum scope of chain cable of 6, the scope being the ratio between the paid-out length of the chain and water depth.

(4) It is assumed that under normal circumstances a ship uses only one bow anchor and chain cable at a time.

6 Sheltered waters are generally calm stretches of water (e.g. harbours, estuaries, roadsteads, bays, lagoons) where the wind force does not exceed 6 on the Beaufort scale.

23.1.2 Equipment Numbers*

1 The equipment number (EN) is the value obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0\left(hB + S_{fun}\right) + 0.1A$$

W: Full load displacement (t)

B: Breadth of ship (m) (See **2.1.4, Part A of the Rules**)

h: Effective height (m) defined as follows:

$$h = a + \sum h_i$$

a: Vertical distance (m), at the midship, from the designed maximum load line to the top of the uppermost continuous deck beam at side

h_i: Height (m) at the centreline of each tier of deckhouses having a breadth greater than $B/4$; for the lowest tier h_1 is to be measured at the centreline from the upper deck or from the notional deck line where there is local discontinuity in the upper deck (See **Fig. CS23.1**)

S_{fun}: Effective front projected area of the funnel (m^2) defined as follows:

$$S_{fun} = A_{FS} - S_{shield}$$

A_{FS}: Front projected area of the funnel (m^2) calculated between the upper deck at the centreline (or the notional deck line where there is local discontinuity in the upper deck) and the effective height h_F. The value for A_{FS} is to be taken as zero if the funnel breadth is $B/4$ or less at all elevations along the funnel's height.

h_F: Effective height of the funnel (m) measured from the upper deck at the centreline (or the notional deck line where there is local discontinuity in the upper deck) and the top of the funnel. The top of the funnel may be taken at the level where the funnel breadth reaches $B/4$.

S_{shield}: Section of front projected area A_{FS} (m^2) which is shielded by all deckhouses having breadth greater than $B/4$. To determine S_{shield}, the deckhouse breadth is assumed B for all deckhouses having breadth greater than $B/4$. (See **Fig. CS23.2**)

A: Side projected area (m^2) of the hull, superstructures, deckhouses and funnels above the designed maximum load line which are within the length of the ship L_2 and also have a breadth greater than $B/4$. The side projected area of the funnel is to be considered in A when A_{FS} is greater than zero. In such cases, the side projected area of the funnel is to be calculated between the upper deck at the centreline (or the notional deck line where there is local discontinuity in the upper deck) and the effective height h_F.

L_2: Length (m) of ship specified in **2.1.2**, **Part A of the Rules** or 0.97 *times* the length of ship on the designed maximum load line, whichever is smaller. The fore end of L_2 is the perpendicular to the designed maximum load draught at the forward side of the stem, and the aft end of L_2 is the perpendicular to the designed maximum load draught at a distance L_2 aft of the fore end of L_2.

Fig. CS23.1 Effective Height

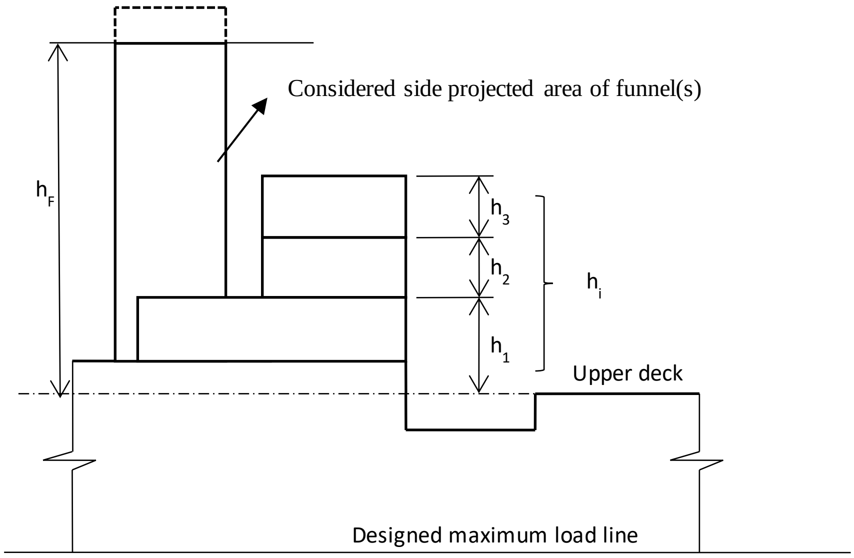
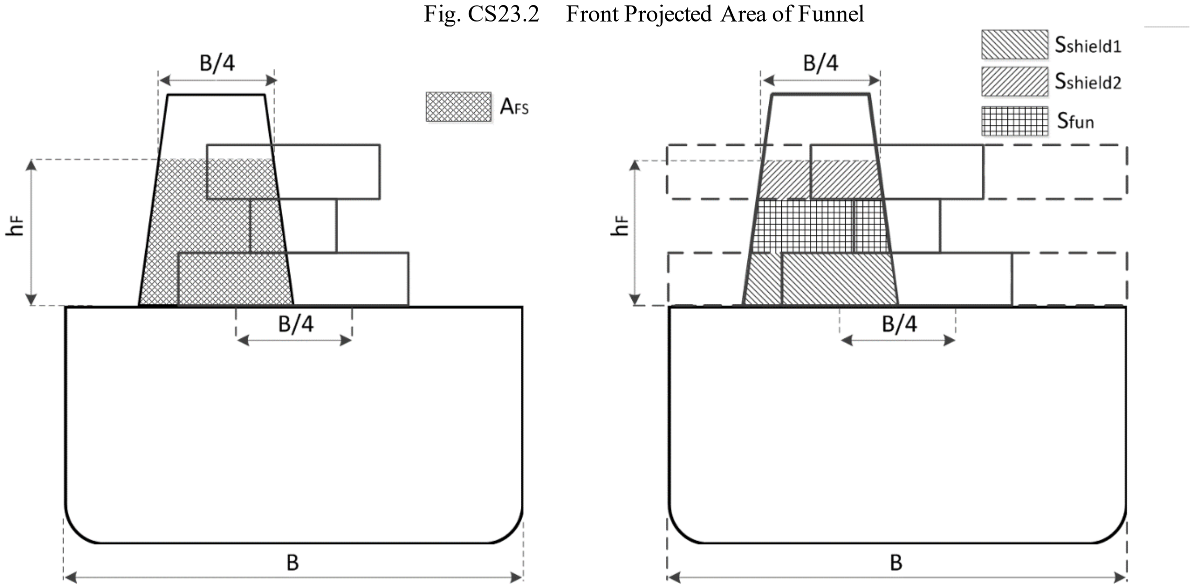
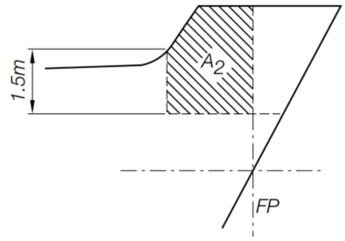


Fig. CS23.2 Front Projected Area of Funnel



2 Screens or bulwarks 1.5 *m* or more in height are to be regarded as parts of deckhouses when determining h and A. The height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A. With regard to determining A, when a bulwark is more than 1.5 *m* high, the area A_2 in **Fig. CS23.3** is to be included in A.

Fig. CS23.3 Effective Area for Screens, Bulwarks, etc.



3 When several funnels are fitted on the ship, the above parameters are to be taken as follows:

h_F: Effective height of the funnel (*m*) measured from the upper deck at the centreline (or the notional deck line where there is local discontinuity in the upper deck) and the top of the highest funnel. The top of the highest funnel may be taken at the level where the sum of each funnel breadth reaches $B/4$.

A_{FS}: Sum of the front projected area of each funnel (m^2) calculated between the upper deck at the centerline (or the notional deck line where there is local discontinuity in the upper deck) and the effective height h_F. The value for A_{FS} is to be taken as zero if the sum of each funnel breadth is $B/4$ or less at all elevations along the funnel's height.

A: Side projected area (m^2) of the hull, superstructures, deckhouses and funnels above the designed maximum load line which are within the length of the ship L_2. The total side projected area of the funnel is to be considered in the side projected area of the ship (A) when A_{FS} is greater than zero. The shielding effect of funnels in transverse direction may be considered in the total side projected area (i.e. when the side projected areas of two or more funnels fully or partially overlap), the overlapped area needs only to be counted once.

4 Notwithstanding **-1**, the equipment number for tugs is to be obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0(aB + \sum h_i b_i) + 0.1A$$

W, a, h_i and A: As specified in **-1** above

b_i: Breadth (*m*) of the widest superstructure or deckhouse of each tier having a breadth greater than $B/4$

23.1.3 Anchors

1 The mass of individual anchors may vary by ±7% of the mass given in **Table CS23.1**, provided that the total mass of anchors is not less than that obtained from multiplying the mass per anchor given in the Table by the number installed on board. However, where approval by the Society is obtained, anchors which are increased in mass by more than 7%may be used.

2 Where stocked anchors are used, the mass excluding the stock is not to be less than 0.80 *times* the mass shown in the table for ordinary stockless anchors.

3 Where high holding power anchors are used, the mass of each anchor may be 0.75 *times* the mass shown in the table for ordinary stockless anchors.

4 Where super high holding power anchors are used, the mass of each anchor may be 0.5 *times* the mass required for ordinary stockless anchors. However, super high holding power anchor mass is generally not to exceed 1,500*kg*.

5 For tugs under 45 *m* in length intended for towing service only, one anchor may be used onboard provided that the second anchor and its relevant chain cable holds readily available to be installed. In case of loss of anchor, the tug is to remain in port until replace anchor equipment is installed onboard.

23.1.4 Chain Cables*

Chain cables for anchors are to be stud link chains of Grade 1, 2 or 3, specified in **3.1** of **Chapter 3**, **Part L**. However, Grade 1 chains made of Class 1 chain bars (*KSBC*31) are not to be used in association with high holding power anchors.

23.1.5 Chain Lockers

1 Chain lockers are to be of capacities and depths adequate to provide an easy direct lead of the cables through the chain pipes and a self-stowing of the cables.

2 Chain lockers including spurling pipes are to be watertight up to the weather deck and to be provided with a means for drainage.

3 Chain lockers are to be subdivided by centreline screen walls.

4 Where a means of access is provided, it is to be closed by a substantial cover and secured by closely spaced bolts.

5 Where a means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements are to be to the satisfaction of the Society. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

6 Spurling pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize water ingress.

7 It is recommended that the inboard ends of the chain cables are to be secured to the structures by fasteners able to withstand a force not less than 15% but not more than 30% of the breaking load of the chain cable.

8 Fasteners are to be provided with a means suitable to permit, in case of emergency, an easy slipping of chain cables to the sea, operable from an accessible position outside the chain locker.

23.1.6 Supporting Hull Structures of Anchor Windlasses and Chain Stoppers

1 The supporting hull structures of anchor windlasses and chain stoppers are to be sufficient to accommodate operating loads and sea loads

(1) Operating loads are to be taken as not less than the following:

(a) For chain stoppers, 80% of the chain cable breaking load

(b) For windlasses, where no chain stopper is fitted or a chain stopper is attached to the windlass, 80% of the chain cable breaking load

(c) For windlasses, where chain stoppers are fitted but not attached to the windlass, 45% of the chain cable breaking load

(2) Sea loads are to be taken according to **2.1.6, Section 4, Chapter 11, Part 1 of Part CSR-B&T of the Rules**

2 The permissible stresses for supporting hull structures of windlasses and chain stoppers are not to be greater than the following permissible values:

(1) For strength assessment by means of beam theory or grillage analysis

(a) Normal stress: 1.00 R_{eH}

(b) Shear stress: 0.60 R_{eH}

R_{eH}: The specified minimum yield stress of the material

(2) For strength assessment by means of finite element analysis

(a) Von Mises stress: 1.00 R_{eH}

(3) The normal stress referred to in **(1)** above is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors are to be considered.

3 For strength assessments of supporting hull structures, beam theory or finite element analysis using net scantlings is to be applied as appropriate. Where finite element analysis is used, the provisions of **23.2.3-5** are to be applied. In addition, the total corrosion addition is to be 2.0 *mm*.

23.2 Towing and Mooring Fittings

23.2.1 General

1 The requirements in **23.2** apply to ships of not less than 500 *gross tonnage*. The requirements in **23.2** apply to shipboard fittings used for towing and mooring operations associated with the normal operation of the ship as well as their supporting hull structures.

2 Ships are to be adequately provided with shipboard fittings which are selected from industry standards deemed appropriate by the Society. The "shipboard fittings" referred to in **23.2** are bollards, bitts, fairleads, stand rollers, chocks used for normal mooring of the ship and other similar components used for normal or other towing of the ship. Other components such as capstans, winches, etc. are not included. Any welds, bolts or equivalent devices connecting shipboard fittings to their supporting structures are considered to be part of the shipboard fitting if selected in accordance with industry standards deemed appropriate by the Society.

3 The definitions of terms which appear in this section are as follows.

(1) Maximum towing load

"Maximum towing load" is the largest load that can be assumed or intended in normal towing such as static bollard pull.

(2) Safe Towing Load (*TOW*)

"Safe Towing Load" (*TOW*) is the safe load limit of shipboard fittings used for towing purpose. However, it does not represent the actual strength of shipboard fittings and their supporting hull structures.

(3) Safe Working Load (*SWL*)

"Safe Working Load" (*SWL*) is the safe load limit of shipboard fittings used for mooring purpose. However, it does not represent the actual strength of shipboard fittings and their supporting hull structures.

(4) Line Design Break Force (*LDBF*)

"Line Design Break Force" (*LDBF*) is the minimum force that a new, dry, spliced, mooring line will break at. This is the cases for all synthetic cordage materials.

(5) Ship Design Minimum Breaking Load (MBL_{sd})

"Ship Design Minimum Breaking Load" (MBL_{sd}) is the minimum breaking load of new, dry mooring lines or tow line for which shipboard fittings and supporting hull structures are designed in order to meet mooring restraint requirements or the towing requirements of other towing services.

(6) Ships intended to be regularly moored to jetty-type piers

Ships intended to be regularly moored to jetty-type piers are oil tankers, chemical tankers or gas carriers which are assumed to be moored to jetty-type piers.

(7) Breast lines, head lines, stern lines and spring lines are defined as follows. (See **Fig. CS23.4**)

(a) Breast line: A mooring line that is deployed perpendicular to the ship, restraining the ship in the off-berth direction.

(b) Spring line: A mooring line that is deployed almost parallel to the ship, restraining the ship in either the fore or aft direction.

(c) Head/Stern line: A mooring line that is oriented between the longitudinal and transverse directions, restraining the ship in the off-berth direction as well as in either the fore or aft direction. The amount of restraint in these directions depends on their relative line angles.

(8) Wind speed for maximum wind speed v_w and acceptable wind speed v_w^*

Wind speed is considered representative of a 30 *second* mean speed from any direction and at a height of 10 *m* above the ground.

(9) Current speed for maximum current speed

The current speed is considered representative of the maximum current speed acting on bow or stern (±10°) and at a depth of one-half of the mean draft. Furthermore, it is considered that ships are moored to solid piers that provide shielding against cross currents.

(10) Ship nominal capacity condition

The ship nominal capacity condition is defined as the theoretical condition in which the maximum possible amount of deck cargoes (in their respective positions) is included in the ship arrangement. For container ships the nominal capacity condition represents the theoretical condition in which the maximum possible number of containers (in their respective positions) is included in the ship arrangement.

(11) Supporting hull structures

Supporting hull structures are the parts of the ship structure on or in which shipboard fittings are placed and which are directly subjected to the forces acting on shipboard fittings.

(12) Sheltered waters

Sheltered waters are generally calm stretches of water (e.g. harbours, estuaries, roadsteads, bays, lagoons) where the wind force does not exceed 6 on the Beaufort scale.

(13) Towing

For the application of this section, towing means the towing operations specified in the following **(a)** and **(b)** but not including **(c)**.

(a) Normal towing means towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operation of the ships

(b) Other towing means towing by another ship or a tug (e.g. such as to assist the ship in cases of emergency)

(c) Towing services not covered by this section are as follows.

i) Escort towing: A towing service for laden oil tankers or LNG carriers, particularly as required in specific estuaries.

Its main purpose is to control the ship in cases of propulsion or steering system failure.

ii) Canal transit towing: A towing service for ships transiting canals (e.g. the Panama Canal).

(14) Mooring area

"Mooring area" refers to the dedicated area on a ship where mooring equipment is installed and line-handling takes place. It also includes areas where there is a risk of personnel injury in event of snap-back or other failure of mooring equipment.

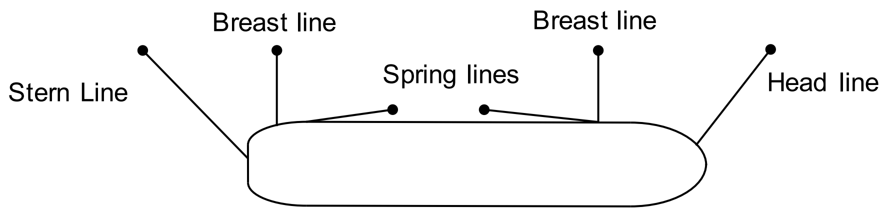
(15) Working Load Limit (*WLL*)

"Working Load Limit (*WLL*)" means the maximum load that a mooring line should be subjected to in operational service, calculated from the relevant environmental mooring restraint requirement.

(16) Bend radius (*D*/*d* ratio)

"Bend radius (*D*/*d* ratio)" means the diameter (*D*) of a mooring fitting divided by the diameter (*d*) of a mooring line that is led around or through the fitting.

Fig. CS23.4 Sample Arrangement of Mooring Lines



23.2.2 Tow Lines

Where ships are provided with tow lines, wire ropes and fibre ropes used as tow lines are to be comply with the requirements in **Chapter 4** and **Chapter 5, Part L of the Rules**, respectively. The specifications of tow lines (e.g. breaking load, length) and the number of tow lines are to be in accordance with **Table CS23.1** according to ship equipment numbers. However, when calculating the equipment number, the effect of deck cargoes at the ship nominal capacity condition is to be considered with respect to the side-projected area *A*.

23.2.3 Towing Fittings

1 Strength

The strength of shipboard fittings used for towing operations at the bow, sides and stern as well as their supporting hull structures are to comply with the requirements of **23.2.3**. For fittings intended to be used for both towing and mooring, the requirements of **23.2.6** are to be applied.

2 Arrangement

(1) Towing fittings are to be located on stiffeners, girders, or both that are part of the deck construction so as to facilitate efficient distribution of the towing load. Other arrangements may be accepted (for chocks in bulwarks, etc.) provided the strength is confirmed adequate for the intended service.

(2) When towing fittings cannot be located as specified in **(1)**, appropriate reinforced members are to be provided directly underneath the towing fittings.

3 Selection

(1) Towing fittings are to be selected from industry standards deemed appropriate by the Society and are to be at least based on the following loads. However, the increase of the line design break force for synthetic ropes (according to **23.2.2(2))** need not be considered for the loads applied to shipboard fittings and their supporting hull structures.

(a) For normal towing operations, the intended maximum towing load.

(b) For other towing services, the minimum breaking strength of the tow line specified in **Table CS23.1** according to the equipment number.

(c) For fittings intended to be used for both normal and other towing operations, the greater of the loads according to **(a)** and **(b)**.

(2) When towing fittings are not selected from industry standards deemed appropriate by the Society, the strength of the fitting and of its attachment to the ship are to be in accordance with **-4** and **-5**. For strength assessments, beam theory or finite element

analysis using net scantlings is to be applied as appropriate. At the discretion of the Society, load tests may be accepted as alternatives to strength assessments by calculations.

(3) Towing bitts (double bollards) are to be of sufficient strength to withstand the loads caused by the tow line attached with an eye splice.

4 Supporting Hull Structures

(1) Design load for the supporting hull structures are to be as specified in **(a)** to **(c)** below:

(a) For normal towing operations, 1.25 *times* the intended maximum towing load.

(b) For other towing services, the breaking load of the tow line specified in **Table CS23.1**.

(c) For fittings intended to be used for both normal and other towing operations, the greater of the design loads specifies in **(1)** and **(2)**.

(2) The reinforced members beneath shipboard fittings are to be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings, and the proper alignment of the fittings and their supporting hull structures is to be ensured. (See **Fig. CS23.5** for a sample arrangement.)

(3) The acting point of the towing force on towing fittings is to be taken as the attachment point of a tow line or at a change in its direction. For bollards and bitts, the attachment point of the tow line is to be taken as not less than 4/5 of the tube height above the base. (See **Fig. CS23.6**)

(4) The design load is to be applied to fittings in all directions that may occur in consideration of the arrangements shown in the towing and mooring arrangements plan specified in **23.2.9**.

(5) Where the tow line is paid-out through a fitting, the design load is to be equal to the resultant force of the design loads acting on the line but need not exceed twice the design load acting on the line. The design load acting on the line is to be the minimum design load specified in **(1)** and **(2)**. (See **Fig. CS23.7**)

(6) The strength of supporting hull structures is to be evaluated based on net scantling calculation.

Fig. CS23.5 Sample Arrangement of Shipboard Fittings and Supporting Hull Structures

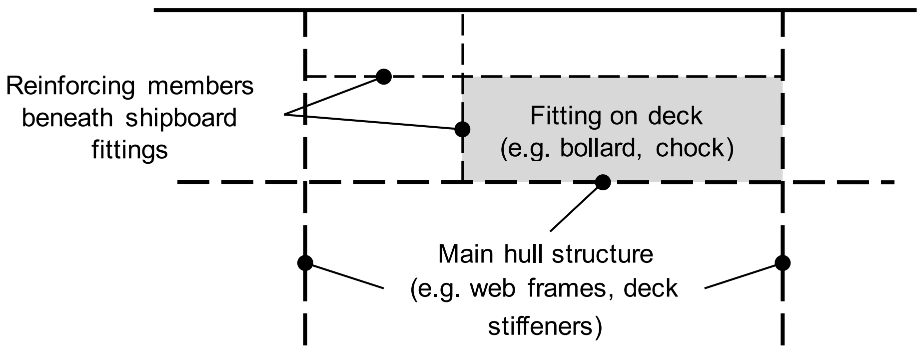


Fig. CS23.6 Acting Point of Towing Force

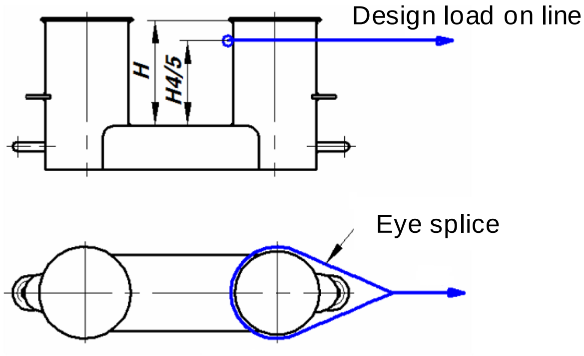
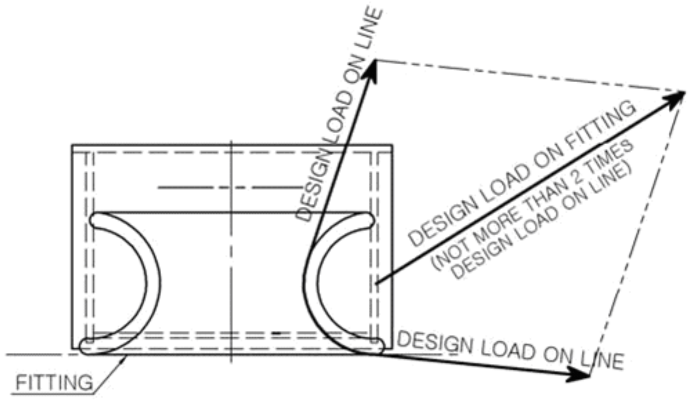


Fig. CS23.7 Design Load



5 Allowable Stresses

Allowable stresses of supporting hull structures are not to be more than the following:

(1) For strength assessments using beam theory or grillage analysis:

(a) Normal stress: 100 % of the specified minimum yield stress of the material

(b) Shearing stress: 60 % of the specified minimum yield stress of the material

(2) For strength assessments using finite element analysis:

(a) Von Mises stress: 100 % of the specified minimum yield stress of the material

(3) The normal stress referred to in **(1)** above is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors are to be considered.

(4) The followings are recommended to be followed for the strength assessment by means of finite element analysis referred to in **(2)** above.

(a) The geometry is to be idealized as realistically as possible.

(b) The ratio of element length to width is not to exceed 3.

(c) Girders are to be modelled using shell or plane stress elements.

(d) Symmetric girder flanges may be modelled by beam or truss elements.

(e) The element height of girder webs is not to exceed one-third of the web height.

(f) In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height.

(g) Large openings are to be modelled

(h) Stiffeners may be modelled by using shell, plane stress, or beam elements.

(i) Stresses are to be read from the centre of the individual element.

(j) For shell elements the stresses are to be evaluated at the mid-plane of the element.

6 Safe Towing Load (*TOW*)

(1) For towing fittings used for the normal towing operations, *TOW* is not to exceed 80 % of the minimum design load specified in **-4(1)(a)**.

(2) For towing fittings used for the other towing operations, *TOW* is not to exceed 80 % of the minimum design load specified in **-4(1)(b)**.

(3) For towing fittings used for both normal and other towing operations, *TOW* is to be the greater of *TOW* according to **(1)** and **(2)**.

(4) The *TOW* (in *tonnes*) of each fitting is to be marked by weld beads and paint, or the equivalent, on the fitting.

(5) The towing and mooring arrangements plan specified in **23.2.9** is to define the method of use of tow lines.

23.2.4 Ship Design Minimum Breaking load (MBL_{sd})

1 MBL_{sd} is the design load for the selection of mooring lines, mooring fittings and for the design of supporting hull structures

2 MBL_{sd} is to be at least not less than minimum breaking load (MBL) specified in **23.2.5**. Where the minimum breaking load is adjusted based on the acceptable wind speed, the number of mooring lines, etc., MBL_{sd} is to be not less than the value MBL^* or MBL^{**}. MBL_{sd} may be determined in accordance with a method deemed appropriate by the Society.

3 Where the MBL_{sd} is determined by the widely recognized industry standards or the owner's standard, MBL_{sd} is to be not less than the minimum breaking load specified in this section.

23.2.5 Mooring Lines

1 General

(1) Ships are to be provided with mooring lines of which *LDBF* is more than MBL_{sd}.

(2) Wire ropes or synthetic ropes used as mooring lines are to comply with the requirements in **Chapter 4** and **Chapter 5, Part L of the Rules,** respectively.

(3) For mooring lines connected with powered winches where the rope is stored on the drum, steel cord wire ropes of suitable flexible construction may be used instead of fibre cord wire ropes subject to the approval by the Society.

(4) The length of individual mooring lines may be reduced by up to 7 % of the lengths required in this section, provided that the actual total length of the stipulated number of mooring lines is not less than the required total length required.

2 The minimum breaking load (*MBL*), the number, the length of mooring lines for ships with equipment numbers of 2,000 or less (EN $\leq$ 2,000) are to be in accordance with the following **(1)** and **(2)**.

(1) The minimum breaking load (*MBL*), the number and the length of mooring lines are to be in accordance with **Table CS23.2** according to the equipment number. However, when calculating the equipment number, the effect of deck cargoes at the ship nominal capacity condition is to be considered with respect to the side-projected area *A*.

(2) For ships having the ratio *A to EN* greater than 0.9 ($A/EN > 0.9$), the following number of ropes are to be added to the number required by **Table CS23.2** for mooring lines.

Where *A/EN* is greater than 0.9 but is 1.1 or less: 1

Where *A/EN* is greater than 1.1 but is 1.2 or less: 2

Where *A/EN* is greater than 1.2: 3

3 The minimum breaking load and the number of mooring lines for ships with an equipment number greater than 2,000 (EN > 2,000) are to be in accordance with **Chapter 14, Part 1, Part C of the Rules**.

4 The arrangement and selection of mooring lines is to in accordance with **14.4.4, Part 1, Part C**.

23.2.6 Mooring Fittings

1 Strength

The strength of shipboard fittings used for towing operations at the bow, sides and stern as well as their supporting hull structures are to comply with the requirements of **23.2.6**. For fittings intended to be used for both towing and mooring, the requirements of **23.2.3** are to be applied.

2 Arrangement

(1) Mooring fittings, mooring winches and capstans are to be located on stiffeners, girders, or both which are parts of the deck construction so as to facilitate efficient distribution of the mooring loads.

(2) When mooring fittings, mooring winches and capstans cannot be located as specified in **(1)**, appropriate reinforced members are to be provided directly underneath the towing fittings.

3 Selection

(1) Mooring fittings are to be selected from industry standards deemed appropriate by the Society and are to be at least based on MBL_{sd}

(2) When mooring fittings are not selected from industry standards deemed appropriate by the Society, the strength of the fitting and of its attachment to the ship are to be in accordance with **-4** and **-5.** For strength assessments, beam theory or finite element analysis using net scantlings is to be applied as appropriate. At the discretion of the Society, load tests may be accepted as alternatives to strength assessments by calculations.

(3) Mooring bitts (double bollards) are to be chosen for the mooring line attached in a figure eight fashion if the industry standard distinguishes between different methods to attach the line (i.e. figure eight or eye splice).

4 Supporting Hull Structure

(1) Design load for supporting hull structures are to be as specified in **(a)** to **(c)** below:

(a) For supporting hull structures of mooring fittings, the minimum design load is to be 1.15 *times* MBL_{sd}

(b) For supporting hull structures of mooring winches, 1.25 *times* the intended maximum brake holding load, where the maximum brake holding load is assumed to be not less than 80 % of MBL_{sd}

(c) For supporting hull structures of capstans, 1.25 *times* the maximum hauling-in force

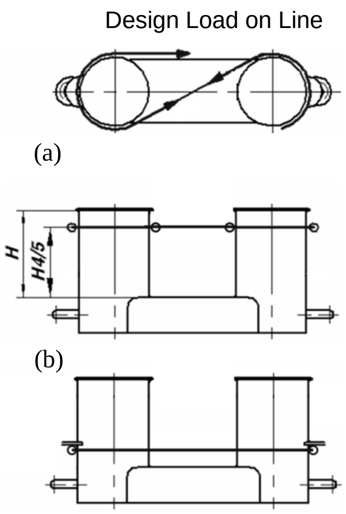
(2) The design load is to be applied to fittings in all directions that may occur in consideration of the arrangements shown in the towing and mooring arrangements plan specified in **23.2.9**.

(3) The point where the mooring force acts on mooring fittings is to be taken as the attachment point of the mooring line. For bollards and bitts, the attachment point of the mooring line is to be taken as not less than 4/5 of the tube height above the base. (See **Fig. CS23.8(a)**) If fins are fitted to the bollard tubes to keep the mooring lines as low as possible, the attachment point of the mooring line may be taken as the location of the fins. (See **Fig. CS23.8(b)**)

(4) Where the mooring line is paid-out through a fitting, the design load is to be equal to the resultant force of the design load acting on the line but need not exceed twice the design load acting on the line. The design load acting on the line is to be the minimum design load specified in **(1)**.

(5) The reinforced members beneath shipboard fittings are to be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings, and the proper alignment of the fittings and their supporting hull structures is to be ensured. (See **Fig. CS23.5** for a sample arrangement.)

Fig. CS23.8 Acting Point of Mooring Force



5 Allowable Stresses

Allowable stresses of supporting hull structures are to be in accordance with **23.2.3-5**.

6 Safe Working Load (*SWL*)

(1) *SWL* is not to exceed MBL_{sd}.

(2) The *SWL* (in *tonnes*) of each fitting, excluding mooring winches and capstan, is to be marked by weld beads and paint, or the

equivalent, on the fitting. For fittings intended to be used for both towing and mooring, *TOW* according to **23.2.3** is to be marked in addition to *SWL*.

(3) The towing and mooring arrangements plan specified in **23.2.9** is to define the method of use of mooring lines.

7 The arrangement and selection of mooring equipment, capstans, and winches are to be in accordance with **14.4.4, Part 1, Part C**.

23.2.7 Corrosion Additions

Corrosion additions are to be added to the scantlings of the supporting hull structures and shipboard fittings as follows:

(1) Supporting hull structures: total of 2.0 *mm*.

(2) Pedestals and foundations fitted on decks which are not shipboard fittings selected from industry standards deemed appropriate by the Society: total of 2.0 *mm*

(3) Shipboard fittings not selected from industry standards deemed appropriate by the Society: total of 2.0 *mm*

23.2.8 Wear Allowances

In addition to the corrosion additions referred to in **23.2.7**, the wear allowances for shipboard fittings not selected from industry standards deemed appropriate by the Society are not to be less than 1.0 *mm*, added to surfaces which are intended to regularly contact the line.

23.2.9 Towing and Mooring Arrangement Plan

1 The *SWL* and *TOW* for the intended use for each shipboard fitting is to be noted in the towing and mooring arrangements plan available on board for the Master. If not otherwise chosen, *TOW* is to be the load limit for a tow line attached with an eye splice.

2 Information provided on the plan is to include the followings;

(1) Industry standard and referenced number of each towing and mooring fittings;

(2) For each towing and mooring fitting, the location on the ship, the purpose (mooring, normal towing, other towing etc.), the *SWL* and/or *TOW* as well as the manner of applying towing or mooring line loads including limiting fleet angles.;

(3) An arrangement of mooring lines showing the number of lines.; (See **Fig. CS23.4**)

(4) The Ship Design Breaking Load MBL_{sd});

(5) The acceptable environmental conditions for ships with equipment numbers greater than 2,000 (EN > 2,000):

(a) Maximum wind speed or acceptable wind speed,

(b) Maximum current speed.

(6) Condition of use for additional mooring equipment not covered by this chapter;

(7) Winch brake holding capacities

(8) For ships of 3,000 gross tonnage and above, documentation confirming that *MSC*.1/*Circ*.1619 has been considered.

(9) The length of each mooring line

(10) Other information or notes related to the design of shipboard fittings or lines.

23.2.10 Inspection and Maintenance of Mooring Equipment Including Mooring Lines

Ships are to have management plans for inspection and maintenance of mooring equipment including mooring lines deemed appropriate by the Society.

23.3 Emergency Towing Procedures

23.3.1 General

1 Ships of not less than 500 *gross tonnage* are to be provided with an emergency towing procedure that describes the towing procedure to be used in emergency situations.

2 The procedure specified in **-1** above is to be based on existing arrangements and equipment available on board the ship and is to include the following:

(1) drawings of fore and aft deck showing possible emergency towing arrangements;

(2) inventory of equipment on board that can be used for emergency towing;

(3) means and methods of communication; and

(4) sample procedures to facilitate the preparation for and conducting of emergency towing operations.

Table CS23.1 Anchors, Chain Cables and Ropes

Equipment Letter	Equipment number		Anchor		Chain cable for anchor (Stud anchor for chain)				Tow line	
			number	Mass per anchor (stock-less anchor)	Total length	Diameter			Length	Breaking load
						Grade 1	Grade 2	Grade 3		
	Over	Up to		*kg*	*m*	*mm*	*mm*	*mm*	*m*	*kN*
A1	50	70	2	180	220	14	12.5		180	98
A2	70	90	2	240	220	16	14		180	98
A3	90	110	2	300	247.5	17.5	16		180	98
A4	110	130	2	360	247.5	19	17.5		180	98
A5	130	150	2	420	275	20.5	17.5		180	98
B1	150	175	2	480	275	22	19		180	98
B2	175	205	2	570	302.5	24	20.5		180	112
B3	205	240	2	660	302.5	26	22	20.5	180	129
B4	240	280	2	780	330	28	24	22	180	150
B5	280	320	2	900	357.5	30	26	24	180	174
C1	320	360	2	1020	357.5	32	28	24	180	207
C2	360	400	2	1140	385	34	30	26	180	224
C3	400	450	2	1290	385	36	32	28	180	250
C4	450	500	2	1440	412.5	38	34	30	180	277
C5	500	550	2	1590	412.5	40	34	30	190	306
D1	550	600	2	1740	440	42	36	32	190	338
D2	600	660	2	1920	440	44	38	34	190	370
D3	660	720	2	2100	440	46	40	36	190	406
D4	720	780	2	2280	467.5	48	42	36	190	441
D5	780	840	2	2460	467.5	50	44	38	190	479
E1	840	910	2	2640	467.5	52	46	40	190	518
E2	910	980	2	2850	495	54	48	42	190	559
E3	980	1060	2	3060	495	56	50	44	200	603
E4	1060	1140	2	3300	495	58	50	46	200	647
E5	1140	1220	2	3540	522.5	60	52	46	200	691
F1	1220	1300	2	3780	522.5	62	54	48	200	738
F2	1300	1390	2	4050	522.5	64	56	50	200	786
F3	1390	1480	2	4320	550	66	58	50	200	836
F4	1480	1570	2	4590	550	68	60	52	220	888
F5	1570	1670	2	4890	550	70	62	54	220	941
G1	1670	1790	2	5250	577.5	73	64	56	220	1024
G2	1790	1930	2	5610	577.5	76	66	58	220	1109
G3	1930	2080	2	6000	577.5	78	68	60	220	1168
G4	2080	2230	2	6450	605	81	70	62	240	1259
G5	2230	2380	2	6900	605	84	73	64	240	1356
H1	2380	2530	2	7350	605	87	76	66	240	1453
H2	2530	2700	2	7800	632.5	90	78	68	260	1471
H3	2700	2870	2	8300	632.5	92	81	70	260	1471
H4	2870	3040	2	8700	632.5	95	84	73	260	1471
H5	3040	3210	2	9300	660	97	84	76	280	1471
J1	3210	3400	2	9900	660	100	87	78	280	1471
J2	3400	3600	2	10500	660	102	90	78	280	1471
J3	3600	3800	2	11100	687.5	105	92	81	300	1471
J4	3800	4000	2	11700	687.5	107	95	84	300	1471
J5	4000	4200	2	12300	687.5	111	97	87	300	1471
K1	4200	4400	2	12900	715	114	100	87	300	1471
K2	4400	4600	2	13500	715	117	102	90	300	1471

*K*3	4600	4800	2	14100	715	120	105	92	300	1471
*K*4	4800	5000	2	14700	742.5	122	107	95	300	1471
*K*5	5000	5200	2	15400	742.5	124	111	97	300	1471
*L*1	5200	5500	2	16100	742.5	127	111	97	300	1471
*L*2	5500	5800	2	16900	742.5	130	114	100	300	1471
*L*3	5800	6100	2	17800	742.5	132	117	102	300	1471
*L*4	6100	6500	2	18800	742.5		120	107	300	1471
*L*5	6500	6900	2	20000	770		124	111	300	1471
*M*1	6900	7400	2	21500	770		127	114	300	1471
*M*2	7400	7900	2	23000	770		132	117	300	1471
*M*3	7900	8400	2	24500	770		137	122	300	1471
*M*4	8400	8900	2	26000	770		142	127	300	1471
*M*5	8900	9400	2	27500	770		147	132	300	1471
*N*1	9400	10000	2	29000	770		152	132	300	1471
*N*2	10000	10700	2	31000	770			137	300	1471
*N*3	10700	11500	2	33000	770			142	300	1471
*N*4	11500	12400	2	35500	770			147	300	1471
*N*5	12400	13400	2	38500	770			152	300	1471
*O*1	13400	14600	2	42000	770			157	300	1471
*O*2	14600	16000	2	46000	770			162	300	1471

Notes:

1. Length of chain cables may include shackles for connection.

2. Alternative methodology using direct force calculation for anchoring equipment described in Appendix B of IACS Recommendation No. 10 may be used. Dredgers are excluded.

Table CS23.2 Mooring Lines for Ships with Equipment Number ≦ 2,000

Equipment Letter	Equipment number		Mooring line		
			Number	Length of each line	Breaking load
	Over	Up to		m	kN
*A*1	50	70	3	80	37
*A*2	70	90	3	100	40
*A*3	90	110	3	110	42
*A*4	110	130	3	110	48
*A*5	130	150	3	120	53
*B*1	150	175	3	120	59
*B*2	175	205	3	120	64
*B*3	205	240	4	120	69
*B*4	240	280	4	120	75
*B*5	280	320	4	140	80
*C*1	320	360	4	140	85
*C*2	360	400	4	140	96
*C*3	400	450	4	140	107
*C*4	450	500	4	140	117
*C*5	500	550	4	160	134
*D*1	550	600	4	160	143
*D*2	600	660	4	160	160
*D*3	660	720	4	160	171
*D*4	720	780	4	170	187
*D*5	780	840	4	170	202
*E*1	840	910	4	170	218
*E*2	910	980	4	170	235
*E*3	980	1060	4	180	250
*E*4	1060	1140	4	180	272
*E*5	1140	1220	4	180	293
*F*1	1220	1300	4	180	309
*F*2	1300	1390	4	180	336
*F*3	1390	1480	4	180	352
*F*4	1480	1570	5	190	352
*F*5	1570	1670	5	190	362
*G*1	1670	1790	5	190	384
*G*2	1790	1930	5	190	411
*G*3	1930	2000	5	190	437

23.4 Container Securing Systems

23.4.1 Container Securing Fittings

Fittings used for container securing are to comply with **14.2.1.1, Part 2-1, Part C**.

Chapter 24 TANKERS

24.1 General

24.1.1 Application

1 The construction and equipment of ships intended to be registered and classed as "tankers" 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.

2 The construction, equipment and scantlings of ships intended to carry liquid cargoes having a vapour pressure (absolute pressure) less than 0.28 *MPa* at 37.8℃ in bulk other than crude oil and petroleum products are to be the satisfaction of the Society, having regard to the properties of the cargoes to be carried.

3 The requirements in this Chapter are for ships with machinery aft having one or more longitudinal bulkheads and a single deck with a single bottom, a double bottom or double hull structures in way of cargo tank part.

4 Where the construction of the ship differs from that specified in **-3** 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 are to be applied.

6 In addition to the requirements specified in **-5**, the relevant requirements in **Chapter 14 in Part D**, **Chapter 4 in Part H**, and **Part R** are to be applied to ships specified in **-1**.

24.1.2 Arrangement and Separation of Spaces

1 In cargo oil spaces, longitudinal and transverse oil-tight bulkheads and swash bulkheads are to be suitably arranged.

2 Cofferdams are to be provided in accordance with the following **(1)** to **(3)**:

(1) Cofferdams of air-tight construction with a sufficient width for access are to be provided at fore and aft terminations of cargo oil spaces and the space between the cargo spaces and accommodation spaces. However, for oil tankers intended to carry cargo oil having a flash point above 60℃, the preceding 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 around cargo oil tanks subject to approval by the Society.

3 All areas where there are cargo oil pumps and cargo oil piping 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 **4.2.3-1.** and **4.2.4, Part H** or machinery with a source of ignition is normally present. However, for oil tankers carrying cargo oil having a flash point above 60℃, the requirements may be suitably modified.

4 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.

5 Ullage openings, sighting ports and tank cleaning openings are not to be arranged in enclosed spaces.

6 The arrangement of openings on the boundaries of superstructures and deckhouses are to be such as to minimize the possibility of accumulation of vapours of cargoes. Due consideration in this regard is to be given to the openings in superstructures and deckhouses when the ship is equipped with cargo piping to load or unload at the stern.

24.2 Minimum Thickness

The thickness of structural members in cargo oil tanks and deep tanks is to be in accordance with the requirements given in **(1)** and **(2)** below:

(1) The thickness of longitudinal, transverse, vertical and horizontal girders, struts, their end brackets and various bulkhead plating

is not to be less than 8 mm.

(2) The thickness of structural members is not to be less than 7 mm.

24.3 Bulkhead Plating

24.3.1 Bulkhead Plating in Cargo Oil Tanks and Deep Tanks

1 Thickness t of bulkhead plating is not to be less than the greater of the values obtained from the following formula when h is substituted with h_1 and h_2:

$$t = 3.6S\sqrt{h} + 3.5 \ (mm)$$

Where:

S: Spacing of stiffeners (m)

h: The following h_1 and h_2 (m) are to be applied to cargo oil tanks:

h_1: Vertical distance from the lower edge of the bulkhead plating under consideration to the top of hatchway
For bulkheads of large tanks, a suitable water head is to be considered.

$h_2 = 0.3\sqrt{L}$

The following h_1 and h_2 (m) are to be applied to deep tanks:

h_1: Vertical distance from the lower edge of the bulkhead plating under consideration to the mid-point between the point on the tank top and the upper end of the overflow pipe

h_2: 0.7 *times* the vertical distance from the lower edge of the bulkhead plating under consideration to the point 2.0 m above the top of overflow pipe

2 For the uppermost and lowermost plating of longitudinal bulkheads, the breadth is not to be less than 0.1 D, and the thickness is not to be less than that obtained from the following formulae:

$t = 1.1S\sqrt{L} + 3.5 \ (mm)$ for the lowermost plating

$t = 0.85S\sqrt{L} + 3.5 \ (mm)$ for the uppermost plating

Where:

S: Spacing of stiffeners (m)

24.3.2 Swash Bulkheads

1 Stiffeners and girders are to be of sufficient strength considering the size of tanks and opening ratios.

2 Thickness t of bulkhead plating is not to be less than the value obtained from the following formula:

$$t = 0.3S\sqrt{L + 150} + 3.5 \ (mm)$$

Where:

S: Spacing of stiffeners (m)

3 In determining the thickness of swash bulkhead plating, sufficient consideration is to be given for buckling.

24.3.3 Trunks

The thicknesses of trunk top plating and side wall plating are to be determined applying the requirements of **24.3.1** in addition to the requirements in **Chapter 17**.

24.4 Frames Stiffeners and Longitudinal Beams

24.4.1 Bottom Longitudinals

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

$$Z = 8.6Shl^2 \ (cm^3)$$

Where:

l : Spacing of floors (m)

S: Spacing of bottom longitudinals (m)

h: Distance (m) from the bottom longitudinals under consideration to the following point above top of keel

$d + 0.026L$

24.4.2 Side Longitudinals

1 The section modulus Z of side longitudinals including bilge longitudinals is not to be less than the greater of the values obtained from the following formulae:

$$Z = 8.6Shl^2 \quad (cm^3)$$

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

Where:

S: Spacing of side longitudinals (m)

l : Spacing of transverses (m)

h: Distance (m) from the side longitudinals under consideration to the following point above top of keel

$d + 0.044L - 0.54$

2 For parts forward and afterward of the midship part, the section modulus of side longitudinals may be gradually reduced to 85% of the value obtained from the requirements in **-1** at the end parts of the ship. However, the section modulus of side longitudinals is not to be less than that required in **-1** under any circumstances for the part between the point 0.15 L from the fore end and the collision bulkhead.

24.4.3 Bulkhead Stiffeners in Cargo Oil Tanks and Deep Tanks

The section modulus Z of stiffeners is not to be less than the value obtained from the following formula:

$$Z = 7CShl^2 \quad (cm^3)$$

Where:

S: Spacing of stiffeners (m)

l : Overall length (m) between supporting points of stiffeners including the length of connected parts at ends Where stiffening girders are provided, the distance to the nearest stiffening girder from the connected heel end or the distance between stiffening girders is to be taken.

h: As specified in **24.3.1-1**

However "from the lower edge of the bulkhead plating under consideration" is to be construed as "from the mid-point of l" for vertical stiffeners; and as "from the mid-point of the upper and lower stiffeners" for horizontal stiffeners.

C: As determined from **Table CS24.1** according to the fixity condition of stiffener ends:

Table CS24.1 Value of C

The other end	One end			
	Rigid fixity by bracket	Soft fixity by bracket	Supported by girders or lug-connection	Snip
Rigid fixity by bracket	0.70	1.15	0.85	1.30
Soft fixity by bracket	1.15	0.85	1.30	1.15
Supported by girders or lug-connection	0.85	1.30	1.00	1.50
Snip	1.30	1.15	1.50	1.50

Notes:

1. Rigid fixity by bracket means the fixity in the connection between double bottom plating or comparable stiffeners within adjoining planes and brackets, or equivalent fixity (*see* **Fig.CS13.1 (a)** of the Rules).
2. Soft fixity by bracket means the fixity in the connection between beams, frames, etc., which are crossing members, and brackets (*see* **Fig.CS13.1 (b)** of the Rules).

24.4.4 Buckling Strength

1 Longitudinal beams, side longitudinals attached to sheer strakes and longitudinal stiffeners attached to the longitudinal bulkhead within 0.1 D 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 and frames, the ratio of depth to thickness is not to exceed 15.

3 The full width of face plates of longitudinal beams and frames is not to be less than that obtained from the following formula:

$69.6\sqrt{d_0 l}$ (mm)

Where:

d_0: Depth (m) of web of longitudinal beams or frames

l: Spacing of transverses (m)

4 Where assembled members, special shape steels or flanged plates are used for frames, beams or stiffeners whose scantlings are specified only in terms of the section modulus, the thickness of the webs is not to be less than that obtained from the following formula. However, where the depth of the webs is intended to be greater than the required level due to reasons other than strength, it may be suitably modified.

$15d_0 + 3.5$ (mm)

Where:

d_0: Depth of web (m)

24.4.5 Vertical Struts

Where a strut is provided midway between floors, the strut is to be subject to the requirements specified in 6.6.3. The section modulus of bottom longitudinals and inner bottom longitudinals fitted with the strut may be reduced to that of 0.72 *times* obtained through applying the requirements in 24.4.1 or 24.4.3.

24.4.6 Other Precautions

The section modulus of longitudinal beams is not to be less than that obtained by applying the requirements in 10.2.3. The section modulus of bottom longitudinals, side longitudinals and longitudinal beams is not to be less than that obtained by applying the requirements in 24.4.3.

24.5 Structural Members in Double Bottoms

24.5.1 Girders

The arrangements and scantlings of girders, floors and various structural members connected to them provided in double bottoms are to be in accordance with the relevant requirements in Chapter 6 in addition to the requirements in this Chapter.

24.5.2 Other Structural Members

Structural members other than specified in 24.5.1 are to be in accordance with the requirements in Chapter 6 in addition to the requirements in this Chapter.

24.6 Structural Members in Double Side Hull

24.6.1 Arrangement

1 Where a ship is provided with double side hull, the width of the double side hull is not to be less than 760 mm.

2 In double side hull, transverses are to be provided at a spacing not exceeding about 3.5 m.

3 In addition to the requirements in -2, the following spaces are to be provided with transverses:

(1) Spaces where solid floors are provided in a double bottom.

(2) Sides of transverse bulkheads

24.6.2 Thickness of Transverses

Thickness of transverses is not to be less than the value obtained from the following formula:

$t = 0.6\sqrt{L} + 2.5$ (mm) For the transverse system

$t = 0.7\sqrt{L} + 2.5$ (mm) For the longitudinal system

24.6.3 Lightening Holes

Within about 0.2 D from inner bottom plating, the diameter of lightening holes provided in transverses in the middle half length of a cargo oil tank is not to exceed about 1/5 of the width of transverses. However, if adequate reinforcements are provided, this requirement may be suitably modified for cases where the length of cargo oil tank is especially short.

24.7 Girders and Transverses in Cargo Oil Tanks and Deep Tanks

24.7.1 Scantlings

1 The section modulus of girders is not to be less than the value obtained from the following formula:

$$Z = 7.13Shl^2 \ (cm^3)$$

Where:

S: Breadth (m) of area supported by girders

l : Overall length of girder (m)

h: As specified in **24.3.1-1**

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.

2 Moment of inertia I of girders is not to be less than the value obtained from the following formula. However, the depth of girders is not to be less than 2.5 *times* the depth of slots.

$$I = 30hl^4 \ (cm^4)$$

Where:

h, l: As specified in **-1**.

3 Thickness t of girders is not to be less than the value obtained from the following formula:

$$t = 10S_1 + 3.5 \ (mm)$$

Where:

S_1: Spacing (m) of stiffeners or depth of girders, whichever is smaller

4 Thickness t of flat bar stiffeners and tripping brackets provided on girders, transverses and stiffeners attached to bulkhead 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.

$$t = 0.5\sqrt{L} + 3.5 \ (mm)$$

5 The thickness of face plates forming a girder is not to be less than the thickness of the webs, and the full width is not to be less than that obtained from the following formula:

$$85.4\sqrt{d_0 l} \ (mm)$$

Where:

d_0: Depth of girder (m)

Where girders are of the balanced girder type, d_0 = depth (m) from the plate surface to face plate.

l: Distance (m) between supporting points of girder

Where effective tripping brackets are provided, they may be regarded as supporting points.

24.7.2 Side Transverses for Ships without Double Side Hull

1 In addition to the requirements in **24.7.1-1**, depth d_0 and the section modulus Z of side transverses in areas carrying cargo oil are not to be less than the value obtained from the following formulae respectively. However, the depth of side transverses is not to be less than 2.5 *times* the depth of slots:

$$d_0 = 0.15l_0 \ (m)$$

$$Z = 8.7k^2Shl_0^2 \ (cm^3)$$

Where:

l_0: Overall length (m) of side transverses, which is equal to the distance between the inner surfaces of face plates of deck transverses and inner bottom plating

S : Spacing of transverses (m)

h : Distance (m) between the mid-point of l_0 and the point above top of the keel as given below:

$$d + 0.044L - 0.54$$

k : Correction factor for brackets obtained from the following formula:

$$k = 1 - \frac{0.65(b_1 + b_2)}{l_0}$$

Where:

b_1, b_2: Length (m) of bracket arm at ends of transverses

2 For ships with trunks, the construction of providing continuous deck transverses across the trunks is to be considered as the standard. The depth of deck transverses that can be regarded as those supported by trunks may be $0.03B$.

24.7.3 Transverses of Ships Having a Shingle Bottom in way of Cargo Tank Part

1 Depth d_0 and section modulus Z of bottom transverses are not to be less than that obtained from the following formulae respectively:

$$d_0 = 0.16 l_0 \ (m)$$

$$Z = 9.7k^2(d + 0.026L)Sl_0^2 \ (cm^3)$$

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

S and k : As specified in **24.7.2-1**.

2 The scantling of transverses of ships having a single bottom in way of cargo tank part is not to be less than that obtained from applying requirements in **24.7.1** and **24.7.2**.

24.8 Strengthening of Forward Bottom

Strengthening of the forward bottom is to be in accordance with the requirements in **6.9** and **16.4.4**.

24.9 Structural Details

24.9.1 General

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 sharply impaired.

2 Sufficient consideration is to be given to the fixity at the ends of principal structural members and their supporting and stiffening systems against out-of-plane deflections, and their construction is to minimize local stress concentrations.

24.9.2 Frames and Stiffeners

Longitudinal beams, frames and stiffeners are to be of continuous structures, or to be connected securely so that their sectional areas at the ends can be properly maintained providing sufficient resistance against bending moments.

24.9.3 Girders and Cross Ties

1 Girders provided within the same plane are to be arranged to avoid sharp changes in strength and rigidity. Brackets of a suitable size are to be provided at the ends of girders, and bracket toes are to be sufficiently rounded.

2 Where the depth of longitudinal girders is large, stiffeners are to be arranged in parallel with the face plates.

3 Tripping brackets are to be provided on the web plate transverses at the inner edge of end brackets, etc. and also at the proper intervals in order to support transverses effectively.

4 The upper and lower end brackets for side transverses and transverses for longitudinal bulkheads and webs in the vicinity are to be suitably stiffened.

24.9.4 Supporting Structures of Independent Prismatic Tanks

The arrangement and scantlings of the supporting structures of the independent prismatic tanks are to be at the discretion of the Society.

24.10 Special Requirements for Corrosion

24.10.1 Thickness of Shell Plating

1 In application of the requirements in **Chapter 16,** the thickness of shell plating forming the casing of cargo oil tanks planned to carry ballast water in ships without a double side hull is not to be less than 0.5 *mm* more than the thickness obtained from the formula given in **16.3.2**.

2 In application of the requirements in this **Chapter**, the thickness of shell plating may be 0.5 *mm* less than the thickness obtained from the formula given in **24.3.1**.

24.10.2 Thickness of Deck Plating

1 In application of the requirements in this **Chapter**, the thickness of freeboard deck plating may be 0.5 *mm* less than the thickness obtained by the formula given in **24.3.1**.

2 In application of the requirements in **Chapter 17,** the thickness of freeboard deck plating in spaces carrying cargo oil is not to be less than 0.5 *mm* more than the thickness obtained from the formula given in **17.4**.

24.10.3 Thickness of Tank Top Plating

1 The thickness of tank top plating in cargo oil tanks and deep tanks is not to be less than 1.0 *mm* more than the thickness obtained from the formula given in **24.3.1**. However, such an addition is not required for the thickness of the inner bottom plating.

24.10.4 Section Modulus of Longitudinal Beams, Frames and Stiffeners

1 The section modulus of longitudinal beams provided on deck plating in spaces carrying cargo oil is not to be less than 1.1 *times* that calculated according to the requirements of **10.2.3**.

2 The section modulus of bottom longitudinals and side longitudinals in cargo oil tanks planned to carry ballast water (except tanks for carrying ballast water only in heavy weather conditions) is not to be less than that obtained from the first formula in the requirements of **24.4.1** and **24.4.2** using a coefficient of 9.3, and the second formula in requirements of **24.4.2** using a coefficient of 3.2 respectively. The section modulus of stiffeners in above mentioned cargo oil tanks is not to be less than that of 1.1 *times* obtained by applying the requirements of **24.4.3**.

24.11 Special Requirements for Hatchways and Freeing Arrangements

24.11.1 Ships Having Unusually Large Freeboards

Ships considered to have an unusually large freeboard may be given special consideration in regards to the requirements in **24.11**.

24.11.2 Hatchway to Cargo Oil Tanks

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 comings is to be suitably stiffened.

2 Hatch covers are to be of steel or other approved materials. The construction of steel hatch covers is to comply with the following requirements **(1)** through **(4)**. The construction of hatch covers of materials other than steel is to be at the discretion of the Society.

(1) The thickness of cover plates is not to be less than 12 *mm*. In ships not exceeding 60 *m*, in length, however, the requirement may be modified.

(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 the cover plates are 15 *mm* or more in thickness, the stiffener 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) The covers are to be secured by fastenings spaced not more than 457 *mm* apart in circular hatchways or 380 *mm* apart and not more than 230 *mm* from the corners in rectangular hatchways.

3 The cover is to be provided with an opening at least 150 *mm* in diameter which is to be so constructed as to be capable of being closed oiltight by means of a screw plug or a cover of peep hole.

4 Hatchway coamings are to be provided with gas cocks or other suitable exhausting devices.

24.11.3 Hatchways to Spaces other than Cargo Oil Tanks

In exposed positions on the freeboard and forecastle decks or on the top of expansion trunks, hatchways serving spaces other than cargo oil tanks are to be provided with steel watertight cover having scantling complying with the requirements in **19.2.4** and **19.2.5**.

24.11.4 Gangway and Access

1 A fore and after permanent gangway complying with the requirements in **21.7.2** is to be provided at the level of the superstructure deck between the midship bridge or deckhouse and the poop or after deckhouse, or equivalent means of access is to be provided to carry out the purpose of the gangway such as passages below deck. Elsewhere, and in ships without midship bridge and 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 accommodation spaces and machinery spaces or between separated crew accommodation spaces.

24.11.5 Freeing Arrangements

1 Ships with bulwarks are to have open rails for at least half the length of the exposed part of the freeboard deck or to have other effective freeing arrangements. The upper edge of the sheer strake is to be kept as low as practicable.

2 Where superstructures are connected by trunks, open rails are to be provided for the whole length of exposed parts of the freeboard deck.

3 Gutter bars greater than 300 *mm* in height fitted around the weather decks of tankers in way of cargo manifolds and cargo piping are to be treated as bulwarks. Freeing ports are to be arranged in accordance with the requirements in **21.2**. Closures attached to the freeing ports for use during loading and discharge operations are to be arranged in such a way that jamming cannot occur while at sea.

Chapter 25 LOADING MANUAL

25.1 General

25.1.1 General*

1 This Chapter applies to ships whose length for freeboard L_f is 65 *m* and above.

2 In order to enable the ship master to arrange for the loading of cargo and ballasting to avoid the occurrence of unacceptable stress in the ship's structure, ships are to be provided with a loading manual approved by the Society. However, for ships deemed appropriate by the Society, the requirements above may be dispensed with.

25.1.2 Loading Manual

The loading manual is to include at least the following items.

(1) The loading conditions on which the design of the ship has been based, including permissible limits of longitudinal still water bending moment and still water shearing force

(2) Results of calculations of longitudinal still water bending moment and still water shearing force corresponding to the loading conditions

(3) Allowable limits of local loads applied to hatch covers, deck, double bottom construction, etc., where deemed necessary by the Society

Chapter 26 MEANS OF ACCESS

26.1 General Rules

26.1.1 General

1 Peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds with relative high bilge hopper tanks, and other similar enclosed spaces are to be provided with means of access, i.e., stages, ladders, steps or other similar facilities for internal examinations in safety. However, such means are not required in aft peak tanks and deep tanks which are exclusively loaded with fuel oil or lubrication oil.

2 Notwithstanding **-1** above, spaces specified in **26.2** are to comply with the requirements of **26.2**.

26.1.2 Means of Access to Spaces

1 Safe access to peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds and other similar enclosed spaces is to be, in general, direct from the open deck and served by at least one access hatchway or manhole and ladder.

2 Notwithstanding **-1** above, safe access to lower spaces of spaces divided vertically, may be from other spaces, subject to consideration of ventilation aspects.

3 Notwithstanding **-1** above, the provision of fixed ladders is not required for spaces not greater than 1.5 *m* in height measuring from the bottom to the top of the open deck on ships of less than 300 *gross tonnage*.

26.1.3 Means of Access within Spaces

1 Peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds and other similar enclosed spaces are to be provided with means of access to hull structures for examination.

2 Where unavoidable obstructions such as hull structural members of not less than 600 *mm* in height impedes access to hull structures within the space, appropriate facilities such as ladders or, steps are to be fitted.

26.1.4 Specifications of Means of Access and Ladders

1 Means of access are to be safe to use.

2 Permanent means of access are to be of robust construction.

26.1.5 Plans for Means of Access

Plans showing the arrangement of means of access to peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds with relative high bilge hopper tanks, and other similar enclosed spaces are to be kept on board.

26.2 Special Requirements for Oil Tankers

26.2.1 Application

This section (**26.2**) applies to each space within the cargo area and fore peak tanks of oil tankers (as defined in **1.3.1(11) of Part B**, of not less than 500 *gross tonnage*), in place of the requirements in **26.1**. Notwithstanding the above, the provisions in this section, except **26.2.3-1** and **-2** and **26.2.5-5**, **-6** and **-7** in relation to access to tanks/spaces, does not need to apply to cargo tanks of combined oil/chemical tankers which are to comply with the requirements for ships carrying dangerous chemicals in bulk as defined in **2.1.43 of Part A**.

26.2.2 General*

Each space within the cargo area and fore peak tanks are to be provided with means of access to enable overall and close-up examinations and thickness measurements of the ship's structures to be carried out safely.

26.2.3 Means of Access to Spaces

1 Safe access to each space within the cargo area and fore peak tanks is to be direct from the open deck and in accordance with the following **(1)** or **(2)** corresponding to the kind of the space.

(1) Tanks, cofferdams and subdivisions of tanks and cofferdams, having a length of not less than 35 *m*, are to be fitted with at least two access hatchways or manholes and ladders, as far apart as is practicable.

(2) Tanks and cofferdams less than 35 *m* in length are to be served by at least one access hatchway or manhole and ladder.

2 Notwithstanding **-1** above, safe access to double bottom spaces, forward ballast tanks or lower spaces of sections divided vertically, may be from a pump-room, deep cofferdam, pipe tunnel, cargo hold, double hull space or similar compartment not intended for the carriage of oil or hazardous cargoes, subject to consideration of ventilation aspects.

3 The uppermost entrance section of the ladder providing access from the deck to a tank or cofferdam is to be vertical for not less than 2.5 *m*, but not in excess of 3.0 *m* measured clear of the overhead obstructions in way of the tank entrance, and be connected to a ladder linking platform which is to be displaced to one side of the vertical ladder. However, where there is a longitudinal or athwartship permanent means of access fitted within 1.6 *m* and 3 *m* below the deck head, the uppermost section of the ladder may stop at this means of access.

4 For oil tankers, access ladders to cargo tanks and other spaces in the cargo area (excluding fore peak tanks) are to be in accordance with the following.

(1) Where two access hatchways or manholes and ladders are required as in **-1(1)** above, at least one ladder is to be of the inclining type. However, the uppermost entrance section of the ladder is to be vertical in accordance with the provisions of **-3** above.

(2) Where ladders not required to be of the inclined type as specified in **(1)** above, maybe of a vertical type. Where the vertical distance is more than 6 *m*, vertical ladders are to be connected by one or more ladder linking platforms, generally spaced not more than 6 *m* apart vertically and displaced to one side of the ladder. The uppermost entrance section of the ladder is to be in accordance with the provisions of **-3** above.

(3) Where one access hatchway or manhole and ladder is required as in **-1(2)** above, an inclined ladder is to be used in accordance with the provisions of **(1)** above.

(4) In double hull spaces of less than 2.5 *m* width, access to the space may be made by means of vertical ladders that are connected to one or more ladder linking platforms generally spaced not more than 6 *m* apart vertically and displaced to one side of the ladder. Adjacent sections of ladder are to be laterally offset from each other by at least the width of the ladder. The uppermost entrance section of the ladder is to be in accordance with the provisions of **-3** above.

(5) Access from the deck to a double bottom space may be made by means of a vertical ladder through a trunk. The vertical distance from the deck to a resting platform, between resting platforms, or a resting platform and the tank bottom is generally not to be more than 6 *m* unless approved otherwise by the Society.

26.2.4 Means of Access within Spaces

1 For oil tankers: cargo oil tanks and water ballast tanks except those specified in **-2** and **-3** are to be provided with means of access in accordance with the following **(1)** to **(4)**.

(1) For tanks of which the height is not less than 6 *m*, permanent means of access are to be provided in accordance with **(a)** to **(f)**.

  (a) A continuous athwartship permanent means of access is to be arranged at each transverse bulkhead on the stiffened surface, at a minimum of 1.6 *m* to a maximum of 3 *m* below the deck head.

  (b) At least one continuous longitudinal permanent means of access is to be provided at each side of the tank. One of these accesses is to be at a minimum of 1.6 *m* to a maximum of 6 *m* below the deck head and the other is to be at a minimum of 1.6 *m* to a maximum of 3 *m* below the deck head.

  (c) Access between the arrangements specified in **(a)** and **(b)** and from the main deck to either **(a)** or **(b)** is to be provided.

  (d) A continuous longitudinal permanent means of access integrated into the structural members on the stiffened surface of a longitudinal bulkhead, in alignment, where possible, with horizontal girders of transverse bulkheads is to be provided for access to transverse webs from the upper deck and tank bottom unless permanent fittings are installed at the uppermost platform for use as an alternative means deemed appropriate by the Society, for inspection at intermediate heights.

  (e) A transverse permanent means of access on the cross-ties providing access to the tie flaring brackets at both sides of the tank, with access from one of the longitudinal permanent means of access in **(d)** for ships having cross-ties which are not less than 6 *m* above the tank bottom.

  (f) An alternative means deemed appropriate by the Society may be provided for small ships with cargo oil tanks less than 17 *m* in height as an alternative to **(d)**.

(2) For tanks less than 6 *m* in height, an alternative means deemed appropriate by the Society or portable means may be utilized in lieu of permanent means of access.

(3) Notwithstanding **(1)** and **(2)** above, tanks not containing internal structures need not to be provided with permanent means of access.

(4) Means of access deemed appropriate by the Society are to be provided for access to under deck structures, transverse webs and

cross-ties outside the reach of permanent and/or portable means of access, as required in **(1)** and **(2)** above.

2 For oil tankers: water ballast wing tanks of less than 5 *m* width forming double side spaces and their bilge hopper sections are to be provided with means of access in accordance with the following **(1)** to **(3)**.

(1) For double side spaces above the upper knuckle point of the bilge hopper sections, permanent means of access are to be provided in accordance with **(a)** to **(c)**:

(a) Where the vertical distance between the uppermost horizontal stringer and the deck head is not less than 6 *m*, one continuous longitudinal permanent means of access is to be provided for the full length of the tank with a means to allow passing through transverse webs installed at a minimum of 1.6 *m* to a maximum of 3 *m* below the deck head with a vertical access ladder at each end of the tank.

(b) A continuous longitudinal permanent means of access integrated in the structure at a vertical distance not exceeding 6 *m* apart is to be provided.

(c) Plated stringers are, as far as possible, to be in alignment with horizontal girders of transverse bulkheads.

(2) For bilge hopper sections of which the vertical distance from the tank bottom to the upper knuckle point is not less than 6 *m*, one longitudinal permanent means of access is to be provided for the full length of the tank in accordance with the following **(a)** and **(b)**. It is to be accessible by a vertical permanent means of access at each end of the tank.

(a) The longitudinal continuous permanent means of access may be installed at a minimum of 1.6 *m* to a maximum of 3 *m* from the top of the bilge hopper section. A platform extending from the longitudinal continuous permanent means of access in way of the web frame may be used to access the identified critical structural areas.

(b) Alternatively, the continuous longitudinal permanent means of access may be installed at a minimum of 1.2 *m* below the top of the clear opening of the web ring allowing the use of portable means of access to reach identified critical structural areas.

(3) Where the vertical distance referred to in **(2)** is less than 6 *m*, alternative means deemed appropriate by the Society or portable means of access may be utilized in lieu of permanent means of access. To facilitate the operation of the alternative means of access, in-line openings in horizontal stringers are to be provided. The openings are to be of an adequate diameter and are to have suitable protective railings.

3 For fore peak tanks with a depth of not less than 6 *m* at the centreline of the collision bulkhead, suitable means of access are to be provided for access to critical areas such as the underdeck structure, stringers, collision bulkhead and side shell structure in accordance with the following **(1)** and **(2)**.

(1) Stringers of less than 6 *m* in vertical distance from the deck head or a stringer immediately above are considered to provide suitable access in combination with portable means of access.

(2) Where vertical distance between the deck head and stringers, stringers or the lowest stringer and the tank bottom is not less than 6 *m*, alternative means of access deemed appropriate by the Society is to be provided.

4 Where the Society deems that a permanent means of access may be susceptible to damage during normal cargo loading and unloading operations or is impracticable to fit a permanent means of access, alternative means of access deemed appropriate by the Society may be utilized in lieu of those specified in **-1** to **-3** above, provided that the means of attaching, rigging, suspending or supporting them forms a permanent part of the ship's structure.

26.2.5 Specifications for Means of Access and Ladders

1 Permanent means of access are, in general, to be integral to the structure of the ship, thus ensuring that they are robust. Where deemed necessary by the Society for facilitating that such means of access are of integral parts of the structure itself, reasonable deviations from the requirements of the position of means of access in **26.2.3** and/or **26.2.4** may be accepted.

2 Elevated passageways forming sections of a permanent means of access, where fitted, are to have a minimum clear width of 600 *mm*, except for going around vertical webs where the minimum clear width may be reduced to 450 *mm*, and have guard rails over the open side of their entire length.

3 Sloping parts of the access are to be of non-skid construction.

4 Elevated passageways forming sections of a permanent means of access, are to be provided with guard rails of 1,000 *mm* in height and consist of a rail and an intermediate bar 500 *mm* in height and of substantial construction, with stanchions not more than 3 *m* apart, on the open side.

5 For access through horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening is not to be less than 600 *mm*×600 *mm*. When access to a cargo hold is arranged through the cargo hatch, the top of the ladder is to be placed as close as possible to the hatch coaming. Access hatch coamings having a height greater than 900 *mm* are also to have steps on the outside in conjunction with the ladder.

6 For access through vertical openings, or manholes, in swash bulkheads, floors, girders and web frames providing passage through the length and breadth of the space, the minimum opening is not to be less than 600 *mm*×800 *mm* at a height of not more than 600 *mm* from the bottom shell plating unless gratings or other foot holds are provided.

7 For oil tankers of less than 5,000 *tonnes deadweight*, smaller dimensions for the openings referred to in **-5** and **-6** 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.

8 Access to permanent means of access and vertical openings from the ship's bottom is to be provided by means of easily accessible passageways, ladders or treads. Treads are to be provided with lateral support for the foot. Where the rungs of ladders are fitted against a vertical surface, the distance from the centre of the rungs to the surface is to be at least 150 *mm*. Where vertical manholes are fitted higher than 600 *mm* above the walking level, access is to be facilitated by means of treads and hand grips with platform landings on both sides.

9 For ladders or similar facilities forming sections of a permanent means of access, their specifications are to the satisfaction of the Society.

26.2.6 Ship Structure Access Manual

1 For every ship, means of access to carry out overall and close-up inspections and thickness measurements are to be described in a Ship Structure Access Manual approved by the Society, and any change of the contents of which is to be updated and an updated copy of which is to be kept on board. The Ship Structure Access Manual is to include the following for each space.

(1) Plans showing the means of access to the space, with appropriate technical specifications and dimensions

(2) Plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions (the plans are to indicate from where each area in the space can be inspected)

(3) Plans showing the means of access within the space to enable close-up inspections to be carried out, with appropriate technical specifications and dimensions (the plans are to indicate the positions of critical structural areas, whether the means of access is permanent or portable and from where each area can be inspected)

(4) Instructions for inspecting and maintaining the structural strength of all means of access and means of attachment, taking into account any corrosive atmosphere that may exist within the space

(5) Safety instructions for when rafting is used for close-up inspections and thickness measurements

(6) Instructions for the rigging and use of any portable means of access in a safe manner

(7) An inventory of all portable means of access

(8) Records of periodical inspections and maintenance of the ship's means of access

2 Where alternative means of access are adapted in accordance with the provisions of **26.2.4**, a means for safe operation and rigging of such alternative means to and from and within the spaces are to be clearly described in the Ship Structure Access Manual.

Chapter 27 SHIPS TO BE CLASSED FOR RESTRICTED SERVICE

27.1 General

27.1.1 Application

1 The requirements of this Chapter are applicable to the ships to be classed for restricted service.

2 The relevant Chapters are to be applied, unless otherwise specified in this Chapter.

27.2 Ships to be Classed for *Coasting Service*

27.2.1 Application

The requirements in **27.2** are applicable to the ships to be classed for *Coasting Service*.

27.2.2 Reductions of Scantlings of Members

1 The scantlings of structural members may be reduced by the ratios given in **Table CS27.1** in relation to the requirements in the relevant Chapters, but in no cases are they to be less than each minimum scantling in the same table.

Table CS27.1 Reductions of Scantlings of Members and Minimum Scantlings

Item	*Coasting*	*Smooth Water*	Minimum Scantlings
Longitudinal strength	5%	10%	-
Shell platings (including plate keels)	5%	10%	6 *mm*, except superstructures
Minimum thickness of deck platings	1 *mm*	1 *mm*	5 *mm*
Section modulus of frames (including bottom longitudinals)	10%	20%	30 cm^3
Section modulus of beams	15%	15%	-
Section modulus of deck girders	15%	15%	-
Thickness of plates of double bottom members	1 *mm*	1 *mm*	5.5 *mm*
Thickness of plates of single bottom members	0.5 *mm*	10% or 1 *mm*, whichever is smaller	-
Plate thickness and section modulus of superstructure end bulkhead	10%	10%	-

2 Reductions of scantlings of members other than given in **Table CS27.1** may be made at the discretion of the Society.

3 The scantlings of the structural members of deck beams supporting deck cargoes, inner bottom plates and longitudinals supporting heavy cargoes and deep tanks and those required in accordance with the provisions of **Annex 1.1, Part 2-2, Part C** are not to be reduced from the values specified in the relevant Chapters, notwithstanding the provisions in **-1**. and **-2**.

4 The design pressure P_e given in **21.3.4-1(1)** and **Table CS21.3** may be multiplied by 0.8.

5 The design pressure of rectangular windows *P* given in **21.5.8-1** may be multiplied by 0.9.

27.2.3 Equipment

1 Equipment is to be in accordance with the requirements of **Chapter 23**.

2 Notwithstanding the provision in **-1**, the mass of one of the two anchors may be reduced to 85% of the mass required in the **Table CS23.1**.

3 Notwithstanding the provision in **-1**, for ships not engaged on international voyage Emergency Towing Procedures specified in **23.3,** are not required.

27.2.4 Height of Hatchway Coamings, etc.

Height of hatchway coamings, sill of doors, etc. may be reduced to the heights specified in **Table CS27.2**.

27.2.5 Means of Access

Where deemed as appropriate by the Society, the requirements specified in 26.2 may be modified.

27.2.6 Means of Embarkation and Disembarkation

For ships not engaged on international voyages, the means of embarkation and disembarkation specified in 21.8 are not required.

Table CS27.2 Heights of Hatchway Coamings, Sills of Doors, etc.(*mm*)

Service Area	Position of Hatchways, etc.	Kind of Hatchways, etc.				
		[A]	[B]	[C]	[D]	[E]
Coasting	I	600	450	450	380	900
	II	450	380	300	300	760
Smooth Water	I	450	380	300	300	760
	II	300	230	100	100	450

Where,

[A] =General hatchways

[B] =Small hatchways, the area of which is not bigger than 1.5 m^2

[C] =Companionways

[D] =Doors of superstructure end bulkheads

[E] =Ventilators

27.3 Ships to be Classed for *Smooth Water Service*

27.3.1 Application

The requirements in 27.3 are applicable to the ships to be classed for *Smooth Water Service*.

27.3.2 Reductions of Scantlings of Members

1 The scantlings of structural members may be reduced by the ratios given in Table CS27.1 in relation to the requirements in the relevant Chapters, but in no cases are they to be less than each minimum scantling in the same table.

2 Reductions of scantlings of members other than given in Table CS27.1 may be made at the discretion of the Society.

3 The scantlings of the structural members of deck beams supporting deck cargoes, inner bottom plates and longitudinals supporting heavy cargoes and deep tanks and those required in accordance with the provisions of Annex 1.1, Part 2-2, Part C are not to be reduced from the values specified in the relevant Chapters, notwithstanding the provisions in -1 and -2.

4 The design pressure P_e given in 21.3.4-1(1) and Table CS21.3 may be multiplied by 0.5.

5 The design pressure of rectangular windows P given in 21.5.8-1 may be multiplied by 0.9.

27.3.3 Height of Hatchway Coamings, etc.

Height of hatchway coamings, sills of doors, etc. may be reduced to the heights specified in Table CS27.2.

27.3.4 Hatchway Covers

1 The hatchway covers may be of shelter type.

2 The thickness of steel hatchway cover, on which cargoes are not carried, may be 4.5 *mm*.

3 Stiffeners are to be provided at suitable intervals in the steel hatchway covers, and the section modulus of stiffeners, on which cargoes are not carried, may be reduced from the value obtained from the formula in **19.2.6-2** taking C as 1.7.

27.3.5 Equipment

Equipment is to be accordance with the requirements in 27.2.3. However, equipment letter in Table CS23.1 may be degraded one rank from the requirements in 23.1.2.

27.3.6 Means of Access

Where deemed as appropriate by the Society, the requirements specified in 26.2 may be modified.

27.3.7 Means of Embarkation and Disembarkation

For ships not engaged on international voyages, the means of embarkation and disembarkation specified in 21.8 are not required.

27.4 Ships Not Engaged On International Voyages

27.4.1 Relaxation to Ships Not Engaged On International Voyages

1 For non-conventional ships, the requirements in **23.2** (excluding **23.2.2** and **23.2.5**) need not to be applied.

2 Ships not engaged on international voyages need not apply the provisions of **21.8**.

3 Ships not engaged on international voyages need not to apply the provisions of **23.3**.

Contents

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CS HULL CONSTRUCTION AND EQUIPMENT OF SMALL SHIPS

CS1 GENERAL

CS1.1 Application and Equivalency

CS1.1.1 Application

1 Even where a ship is intended to be classified for restricted services, the provisions in **27.2.4**, **27.3.3** and **27.3.4, Part CS** of the Rules cannot be applied as far as the "International Convention on Load Lines, 1966" (as may be amended) is to apply to the ship.

2 In cases where a ship is engaged in international voyages and is not subject to the "International Convention on Load Lines, 1966" (as may be amended), the Society may require the ship comply with provisions equivalent to those of the "International Convention on Load Lines, 1966" (as may be amended).

3 With respect to the provisions of **1.1.1-5, Part CS** of the Rules, bulk carriers as defined in **An1.2.1(2), Annex 1.1, Part 2-2, Part C** of the Rules, of 500 *gross tonnage* and above, are to apply the provisions of **3.3.5.2-2, Part 1**, **3.2.1.1, Part 2-2,** and **An6.1.1-3, Annex 1.1, Part 2-2, Part C** of the Rules. In this case, for the application to ships of less than 65 *m* in length L_f, loading manuals as specified in **An1.2.1(1), Annex 1.1, Part 2-2, Part C** of the Rules are to read as stability information booklets as required in **1.2.1, Part U** of the Rules. The provisions of **3.2.1.1, Part 2-2, Part C of the Rules** need not apply to such ships. Notwithstanding the above, such ships not engaged on international voyages need not to apply the provisions of **3.3.5.2-2, Part 1, Part C of the Rules**.

CS1.1.3 Ships of Unusual Form or Proportion, or Intended for Carriage of Special Cargoes

1 Ships Having Unusually Large Freeboards

(1) "Ships having unusually large freeboards" are the ships having freeboards that comply with following formula.

$f_s \geq h_s + f$

f_s: Actual summer freeboard (mm) assigned by the requirements in **V2.2.1**

h_s: Standard height (mm) of superstructure determined by the requirements in **V2.2.1**

f : Minimum summer freeboard (mm) determined by the requirements in **Part V of the Rules** on the basis of an assumed freeboard deck which is measured down from the actual freeboard deck by h_s

(2) Ships having unusually large freeboards may be treated as follows where the requirements in **Part CS of the Rules** apply. However, the undermentioned treatment is not to apply to ships whose assigned freeboards are "*B*-60" or "*B*-100" type specified in **Part V of the Rules**.

(a) In the provision of "*h*" specified in **5.4.3, Part CS of the Rules**, "*D*" may be replaced with "*D*′" which is the vertical distance from the top of the keel to an assumed freeboard deck.

(b) The requirements in **7.5.2-1, Part CS of the Rules** may be applied to tween deck frames above an assumed freeboard deck even if they are located below the actual freeboard deck.

(c) In the provision of "*h*" specified in **17.1.1-2, Part CS of the Rules**, a weather deck may be regarded as follows in relation to H_D which is the vertical distance from an assumed freeboard deck to the weather deck at side. The same may be applied to other chapters in **Part CS of the Rules** where "*h*" is used.

$h_s \leq H_D < 2h_s$: Superstructure deck of first tier above the freeboard deck

$2h_s \leq H_D < 3h_s$: Superstructure deck of second tier above the freeboard deck

$3h_s \leq H_D$: Superstructure deck of third tier above the freeboard deck

(d) The thickness of side shell plating located above the imaginary freeboard deck is to be obtained according to the following.

i) The thickness of side shell plating from the imaginary freeboard deck to a height of $2h_s$ above the imaginary freeboard deck is to be obtained from the formulae in **16.3.2, Part CS** of the Rules, where $(d + 0.04L)$ in the first term may be replaced by $(d + 0.04L)D/(D + 2h_s)$

Where

h_s: Standard height of superstructures specified in **V2.2.1**

ii) The thickness of superstructure side plating from a height equal to twice h_s (as per **i)**) above the freeboard deck to the strength deck is not to be less than that obtained from the following formula:

$0.7\sqrt{(L+50)}$ (mm)

iii) The thickness of superstructure side plating from the freeboard deck to a height h_s (as per **i)**) above the freeboard deck forward of $0.25L_f$ aft of F.P. is not to be less than that obtained from **i)** above or **16.5.2, Part CS** of the Rules, whichever is greater.

(e) The interpretation of **(c)** above may be applied to the provision of "*h*" specified in **18.2.1-1, Part CS of the Rules**.

(f)

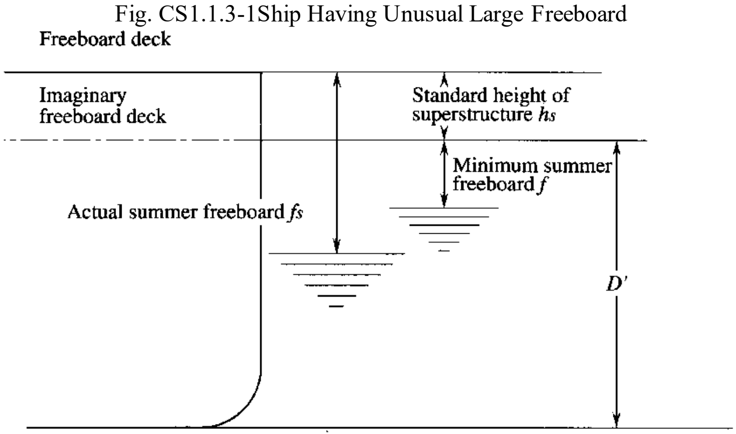
i) The interpretation of **(c)** above may be applied to the provision of "Position of Exposed Deck Openings" in **19.1.2, Part CS of the Rules**. The same may be applied to other chapters in **Part CS** and **Part D of the Rules** where this provision is used.

ii) In Note(*3) of **Table CS19.2**, **Part CS of the Rules**, "freeboard deck" may read as "assumed freeboard deck".

(g) In the application of the requirements in **21.1**, **21.2** and **21.5, Part CS of the Rules**, "freeboard deck" may be read as "assumed freeboard deck" and the interpretation of **(c)** above may be applied when determining the position of the deck. However, side scuttles for spaces below the actual freeboard deck or spaces considered as buoyancy in stability calculations are to be class *A* side scuttles, class *B* side scuttles, or equivalent thereto. In such cases, the deadlight is not to be omitted.

(h) In **13.5.3, Part D**, D' may be used in place of *D* in determining the diameters of bilge suction pipes.

Fig. CS1.1.3-1Ship Having Unusual Large Freeboard



2 Ships Having Unusually Reduced Freeboards

"Ships having unusually reduced freeboards" are ships whose freeboards are of the "*A*", "*B*-60" or "*B*-100" type, assigned in accordance with the requirements in **Part V of the Rules**.

CS1.3 Materials, Scantlings, Welding and End Connections

CS1.3.1 Materials

1 Where high tensile steel are used, the construction and scantlings are to be determined in accordance with **Annex CS1.3.1-1 "GUIDANCE FOR HULL CONSTRUCTION CONTAINING HIGH TENSILE STEEL MEMBERS"**.

2 Where the requirements in **1.3.1-2(3), Part CS of the Rules** are applied, data corresponding to the standard of steels used (extent of their use, location of structural members, section rigidity, fatigue strength, minimum thickness, etc.) is to be submitted to the Society and approved.

3 When the requirements in **1.3.1-4(1), Part CS of the Rules** are applied, data corresponding to the standard of steels used (e.g., extent of use, location of structural members, section rigidity, buckling strength, minimum thickness, etc.) is to be submitted to the Society for approval when deemed necessary.

4 The requirements of **1.3.1-4(2), Part CS of the Rules** apply to members which do not come in contact with sea water, and the values in **(1)** and **(2)** may be deducted from the scantlings required by relevant requirements.

(1) For stainless steel

(a) Where the scantling is determined by the thickness of the plate: 1.0 *mm*

(b) Where the scantling is determined by the section modulus: 5%

(2) For stainless clad steel

Where the scantling is determined by the thickness of plate: 0.5*mm*

5 "Areas of anticipated stress concentration" specified in **1.3.1-4(3) Part CS of the Rules** refers to, for example, the connections of the lower corner parts of corrugated bulkheads and inner bottom plates or the top plate of the lower stools, the connections of inner bottom plates and bilge hopper plates or lower stools, etc.

6 "Where deemed appropriate by the Society" specified in **1.3.1-4(3) Part CS of the Rules** refers to cases such as where fatigue strength assessments based upon hot spot stresses obtained using the finite element method are carried out and the results are submitted to the Society for approval.

7 In cases where it has been deemed appropriate by the Society, fiber reinforced plastic (FRP) may be used for equipment specified in this Part. In this case, such usage is subject to the requirements given in **Annex 3.2, Part 1, Part C of the Rules**.

CS2 STEMS AND STERN FRAMES

CS2.1 Stems

CS2.1.1 Plate Stems

1 The thickness of plate stems may be the same as that of side shell plating at the level of the freeboard deck and the same as that of the forecastle-side shell in the range of the forecastle.

2 Where the plate stem with a large radius of curvature at its fore end is not fitted with a centreline stiffener or is not reinforced by using thicker plate in accordance with **2.1.1-1, Part CS** of the Rules, horizontal breasthooks are to be provided at a space not exceeding 600 *mm* apart for reinforcement.

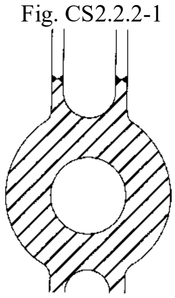
CS2.2 Stern Frames

CS2.2.2 Propeller Posts

1 Connection of cast steel boss and plate parts of built-up stern frame

The connection of a cast steel boss and built-up stern frame is to be well grooved and welded with full penetrations at the root as shown in **Fig. CS2.2.2-1**. A cast steel boss having a shape different from that shown in **Fig. CS2.2.2-1** may be used if enough consideration is paid to workmanship, at the discretion of the Society.

Fig. CS2.2.2-1



2 Length of shaft hole of propeller boss

The length of the shaft hole of the propeller boss is to be greater than 1.25 *times* the inside diameter of the boss hole. Where the length of the shaft hole is less than the length of the bearing prescribed in **6.2.10, Part D** of the Rules, it is recommended that the length of the shaft hole be adjusted to match that of the bearing.

3 Round bars used for built-up stern frame

Where a round bar is used as the aft edge of a built-up stern frame, the standard radius of the round bar is at least 70% of $R(0.40L+16)$ prescribed in **2.2.2, Part CS** of the Rules. At the connection of the round bar to the cast steel part or at the connection of round bars, the depth of the bevel for welding is to be at least 1/3 the diameter of the round bar.

4 The standard thickness of ribs fitted to the stern frame is 75% of the stern frame plate. (*See* **Fig. CS2.2.3-1**)

CS2.2.3 Shoe Pieces

1 Connection of shoe pieces and propeller posts

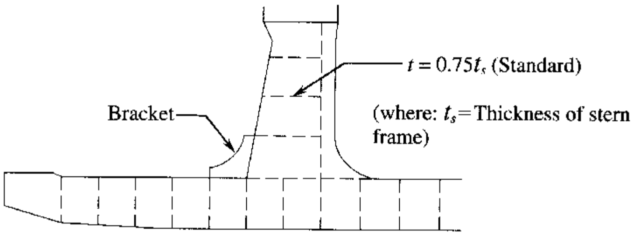
The top plate of the shoe piece is to be extended forward beyond the aft end of the propeller post. A bracket of the same thickness as the stern frame is to be fitted at the connection of the shoe piece and the aft end of the propeller post to keep a sufficient continuity of strength. (*See* **Fig. CS2.2.3-1**)

2 Steel bolts for fixing zinc slabs to the shoe piece must not be directly screwed into the shoe piece. They are to be directly welded to the shoe piece or screwed into steel plates welded to the shoe piece.

3 Shoe pieces of built-up construction are to be made watertight and the inside coated with effective coating material. Where no coating is applied to the inside of the built-up shoe piece, the thickness of the shoe piece is to be increased by 1.5 *mm*.

4 Refer to **CS2.2.2-4** above.

Fig. CS2.2.3-1



CS2.2.4 Heel Pieces

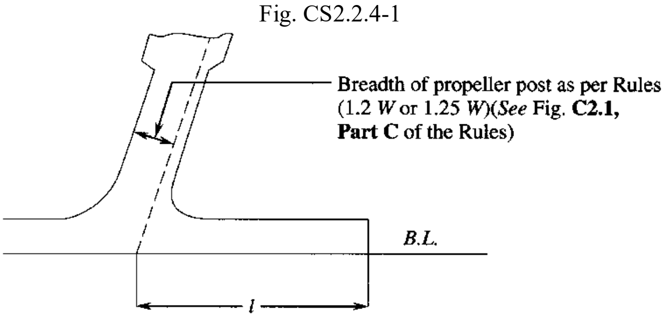
Determination of length of heel pieces

(1) In built-up stern frames, the length of heel pieces may be equal to twice the frame spacing at the position of the heel pieces providing that the thickness of flat keels connected to the heel pieces is increased by 5 *mm*.

(2) The length of heel pieces is to be measured as shown in **Fig. CS2.2.4-1**.

(3) Refer to **CS2.2.2-4** also.

Fig. CS2.2.4-1



CS3 RUDDERS

CS3.1 General

CS3.1.1 Application

1 For Mariner-type rudders (*See* **Fig. 13.2.1-1 (D) and (E)**, **Chapter 13, Part 1, Part C** of the Rules), the scantling of rudders is to be determined in accordance with the requirements in **Chapter 13, Part 1, Part C** of the Rules.

2 The scantling of each member of rudders having three or more pintles is to be determined in accordance with the requirements in **Chapter 3, Part CS** of the Rules. However, the moment and force acting on each member are to be determined by the direct calculation method, in accordance with the requirements in **CS3.4**.

3 Rudders having a special shape or sectional form are to be in accordance with following **(1)** and **(2)**.

(1) The scantling of each member of nozzle rudders is to be determined in accordance with the requirements in **Chapter 3, Part CS** of the Rules, unless the rudder force and rudder torque are required to be determined by tests or detailed theoretical calculation. In applying the Rules, the total rudder area and the rudder area ahead of the centreline of the rudder stock are to be calculated as follows:

Total rudder area A:

$2h(b_1+b_2)+h'(a_1+a_2)\ \ (m^2)$

Rudder area ahead of the centreline of the rudder stock A_f:

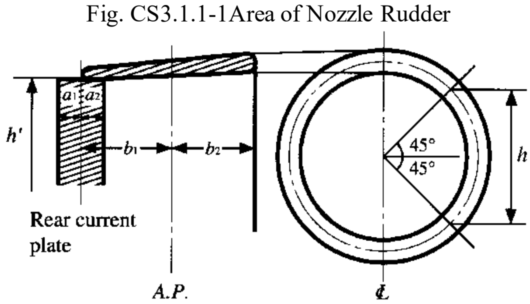
$2hb_2\ \ (m^2)$

Where:

a_1, a_2, b_1, b_2, h and h': Refer to **Fig. CS3.1.1-1**

(2) In other rudders, the scantling of each member is to be determined by obtaining the rudder force and rudder torque through tests or detailed theoretical calculations, and correspondingly applying the requirements in **Chapter 3, Part CS** of the Rules. Results of tests or theoretical calculations are to be submitted to the Society.

Fig. CS3.1.1-1Area of Nozzle Rudder



4 The scantling of each member of rudders designed for helm angles exceeding 35° is to be determined in accordance with the requirements in **Chapter 3, Part CS** of the Rules, on the basis of the rudder force and rudder torque obtained through tests or detailed theoretical calculations. The results of tests and theoretical calculations are to be submitted to the Society.

CS3.1.2 Materials

1 If the diameter of the rudder stock is small, cast carbon steel is not to be used.

2 Rolled bar steel (*KSFR*45) may be treated in the same way as *KSF*45.

CS3.1.4 Equivalence

Where steel castings with a yield stress of less than 205 N/mm^2 are used for rudder main pieces according to the provisions of **3.1.4**, **Part CS of the Rules**, the Society may require that consideration be given to the yield stress of such castings with respect to the application of the allowable stress of rudder main pieces in way of the recesses specified in **3.6.3-3(2)**, **Part CS of the Rules**.

CS3.2 Rudder Force

For single plate rudders, factor K_2 is to be 1.0 for both the ahead and astern conditions.

CS3.4 Rudder Strength Calculation

CS3.4.1 Rudder Strength Calculation

1 General

The bending moment, shear force, and supporting force acting on the rudder and rudder stock may be evaluated using the basic rudder models shown in **Fig. CS3.4.1-1** to **Fig. CS3.4.1-4**.

2 Moments and forces to be evaluated

The bending moment M_R and the shear force Q_1 acting on the rudder body, the bending moment M_b acting on the bearing, and the bending moment M_s acting on the coupling between the rudder stock and the rudder main piece and the supporting forces B_1, B_2, B_3 are to be obtained. These moments and forces are to be used for analyzing the stresses in accordance with the requirements in **Chapter 3, Part CS** of the Rules.

3 Method of evaluating moments and forces

The method of evaluating moments and forces is to be as in the following **(1)** to **(3)** below.

(1) General data

Data on the basic rudder models shown in **Fig. CS3.4.1-1** to **Fig. CS3.4.1-4** is as follows:

l_{10}~l_{50} : Lengths (m) of individual girders of the system

I_{10}~I_{50} : Moments (cm^4) of inertia of these girders

For rudders supported by a shoe piece, the length l_{20} is the distance between the lower edge of the rudder body and the centre of the shoe piece and I_{20} is the moment of inertia of the pintle in the shoe piece.

h_c is the vertical distance (m) from the mid-point of the length of that pintle to the centroid of the rudder area.

(2) Direct calculation

The standard data to be used for direct calculation are as follows:

Load acting on rudder body (Type B rudder)

$$P_R = \frac{F_R}{1000 l_{10}} \ (kN/m)$$

Load acting on rudder body (Type C rudder)

$$P_R = \frac{F_R}{1000 l_{10}} \ (kN/m)$$

Notwithstanding the above, the value is as follows for rudders with rudder trunks supporting rudder stocks.

$$P_R = \frac{F_R}{1000 (l_{10}+l_{20})} \ (kN/m)$$

Load acting on rudder body (Type A rudder)

$$P_{R10} = \frac{F_{R2}}{1000 l_{10}} \ (kN/m)$$

$$P_{R20} = \frac{F_{R1}}{1000 l_{30}} \ (kN/m)$$

Where:

F_R, F_{R1}, F_{R2}: As specified in **3.2** and **3.3, Part CS** of the Rules

k: Spring constant of the supporting point of the shoe piece or rudder horn respectively, as shown below

For the supporting point of the shoe piece:

$$k = \frac{6.18 I_{50}}{l_{50}^{\ 3}} \ (kN/m)$$

(*See* **Fig. CS3.4.1-1** and **Fig. CS3.4.1-2**)

Where:

I_{50}: The moment (cm^4) of inertia of shoe piece around the Z-axis

l_{50}: Effective length (m) of shoe piece

For the supporting point of rudder horn:

$$k = \frac{1}{f_b + f_t} \ (kN/m)$$

(*See* **Fig. CS3.4.1-1**)

Where:

f_b: Unit displacement of rudder horn due to a unit force of 1 kN acting in the centre of support as shown below.

$$f_b = 1.3 \frac{d^3}{6.18 I_n} \ (m/kN)$$

Where:

I_n: The moment (cm^4) of inertia of rudder horn around the X-axis

f_t: Unit displacement due to torsion, as shown below.

$$f_t = \frac{dc^2 \Sigma u_i / t_i}{3.14 {F_T}^2} \times 10^{-8} \ (m/kN)$$

F_T: Mean sectional area (m^2) of the rudder horn

u_i: Breadth (mm) of the individual plates forming the mean sectional area of the rudder horn

t_i: Plate thickness (mm) within the individual breadth u_i

(3) Simplified method

The moments and forces for rudders of each type may be obtained from the following formulae.

(a) Type A rudders

$$M_R = \frac{{B_1}^2 (l_{10} + l_{30})}{2 F_R} \ (N\text{-}m)$$

$$M_b = \frac{B_3 (l_{30} + l_{40})(l_{10} + l_{30})^2}{l_{10}^2} \ (N\text{-}m)$$

$$M_s = B_3 l_{40} \ (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{10}} \ (N)$$

$$B_2 = F_R - 0.8 B_1 + B_3 \ (N)$$

$$B_3 = \frac{F_R {l_{10}}^2}{8 l_{40} (l_{10} + l_{30} + l_{40})} \ (N)$$

(b) Type B rudders

$$M_R = \frac{{B_1}^2 l_{10}}{2 F_R} \ (N\text{-}m)$$

$$M_b = B_3 l_{40} \ (N\text{-}m)$$

$$M_s = \frac{3 M_R l_{30}}{l_{10} + l_{30}} \ (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{10} + l_{30}} \ (N)$$

$$B_2 = F_R - 0.8 B_1 + B_3$$

$$B_3 = \frac{F_R (l_{10} + l_{30})^2}{8 l_{40} (l_{10} + l_{30} + l_{40})} \ (N)$$

(c) Type C rudders

$$M_b = F_R h_c \ (N\text{-}m)$$

$$B_2 = F_R + B_3 \ (N)$$

$B_3 = \frac{M_b}{l_{40}}$ (N)

The maximum moment M_c in top of the cone coupling (as shown in **Fig. CS3.4.1-3**) is applicable for the connection between the rudder and the rudder stocks.

Notwithstanding the above, the strength is to be checked against the following two cases for rudders with rudder trunks supporting rudder stocks.

i) pressure applied on the entire rudder area;

ii) pressure applied only on rudder area below the middle of the neck bearing.

The moments and forces for the two cases defined above may be determined according to **Fig. CS3.4.1-4** and **Fig. CS3.4.1-5**, respectively.

$M_{FR1} = F_{R1} (CG_{1Z} - \ell_{10})$

$M_{FR2} = F_{R2} (\ell_{10} - CG_{2Z})$

where A_1 and A_2 are the rudder blade area which are above the lower bearing and below respectively and symbols are as follows (*See* **Fig. CS3.4.1-4** and **Fig. CS3.4.1-5**)

F_{R1} : Rudder force over the rudder blade area A_1

F_{R2} : Rudder force over the rudder blade area A_2

CG_{1Z}: Vertical position of the centre of gravity of the rudder blade area A_1 from base

CG_{2Z}: Vertical position of the centre of gravity of the rudder blade area A_2 from base

$F_R = F_{R1} + F_{R2}$

$B_2 = F_R + B_3$

$B_3 = \frac{M_{FR2} - M_{FR1}}{\ell_{20} + \ell_{40}}$

Fig. CS3.4.1-1Type A Rudder

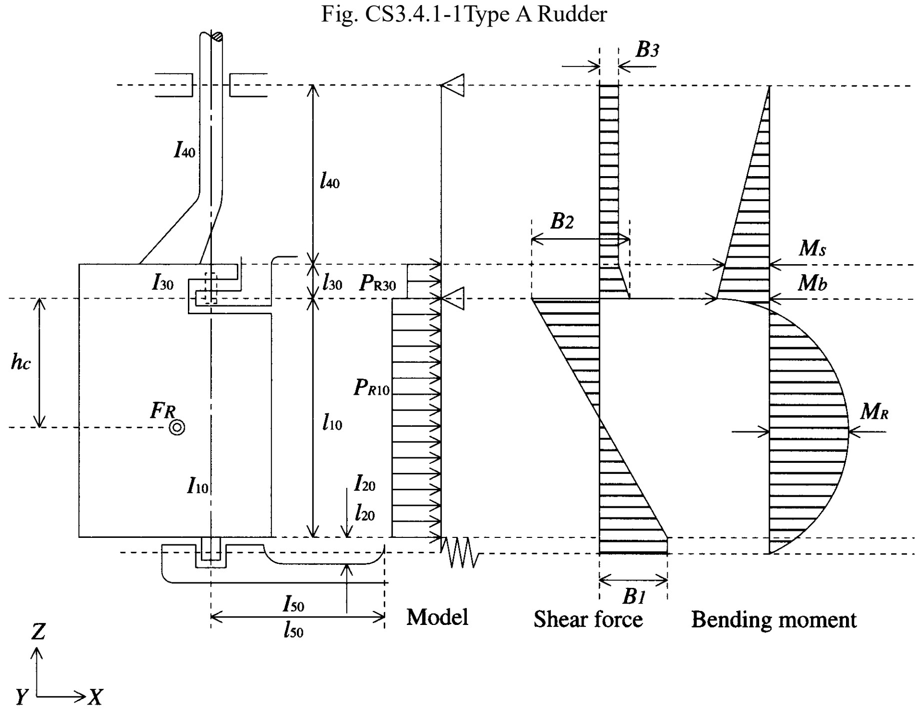


Fig. CS3.4.1-2Type *B* Rudder

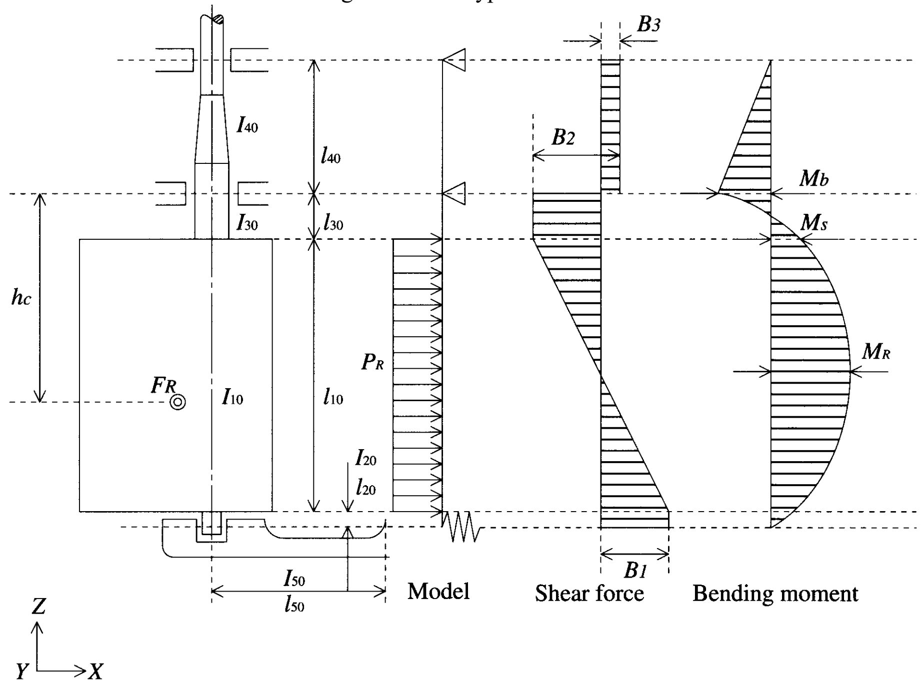


Fig. CS3.4.1-3Type *C* Rudder

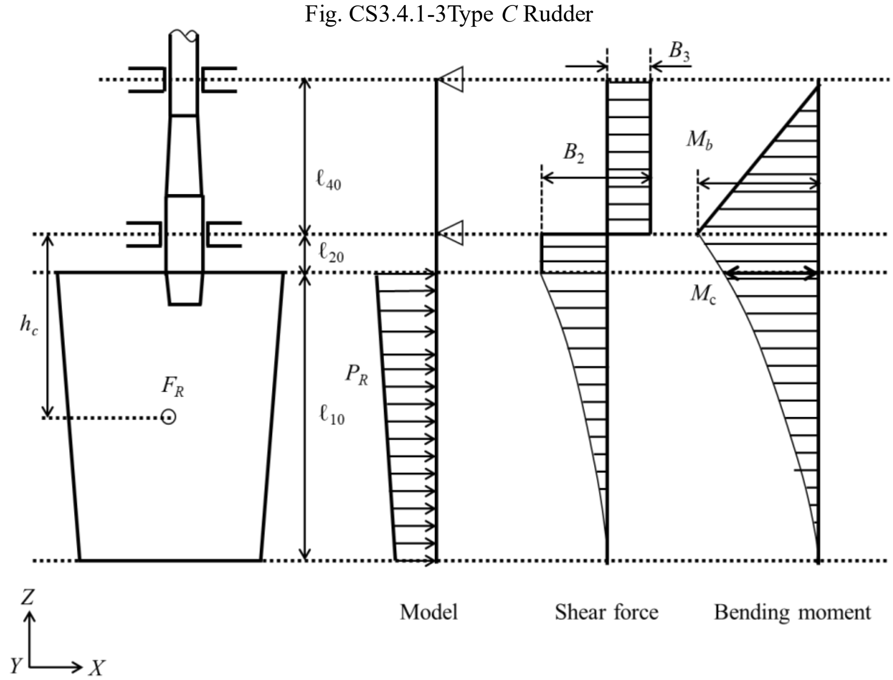


Fig. CS3.4.1-4Type *C* Rudder with Rudder Trunk Supporting Rudder Stock (Pressure Applied on the Entire Rudder Area)

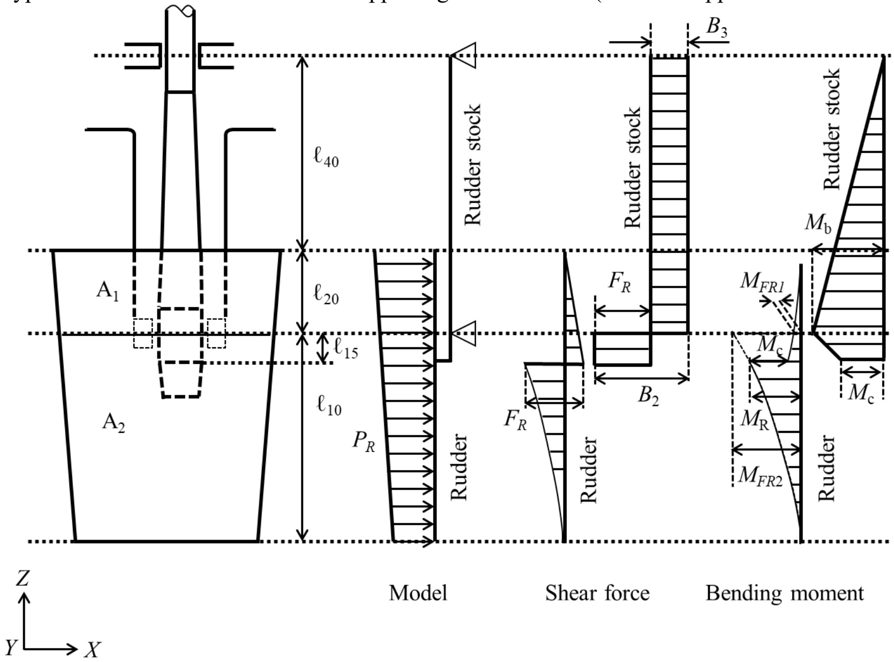
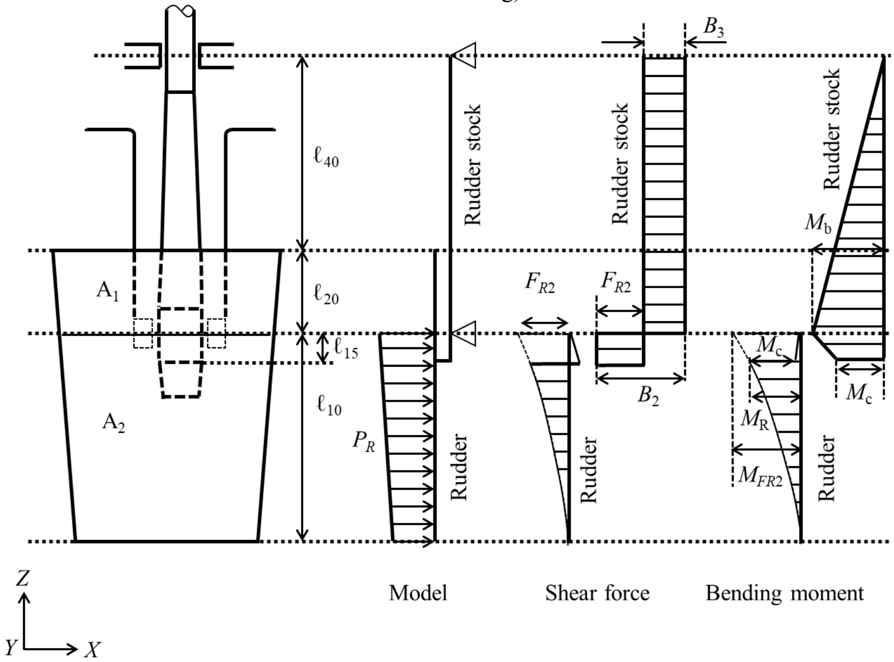


Fig. CS3.4.1-5Type *C* Rudder with Rudder Trunk Supporting Rudder Stock (Pressure applied only on rudder area below the middle of neck bearing)



CS3.5 Rudder Stocks

CS3.5.1 Upper Stocks

1 Taper of upper stock at joint with tiller

Where the upper stocks are tapered for fitting the tiller, the taper is not to exceed 1/25 of the radius or 1/12.5 of the diameter.

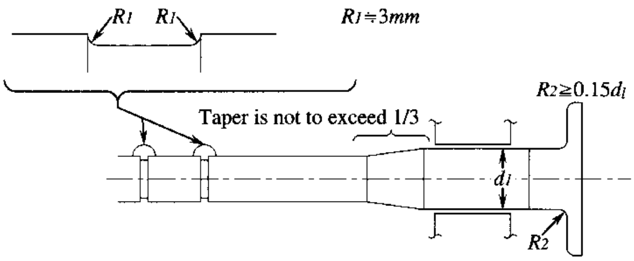
2 Keyways

(1) The depth of the keyway may be neglected in determining the diameter of the rudder stock.

(2) All corners of keyways are to be properly rounded.

3 Each part of the rudder stocks of Type *B* and *C* rudders specified in **3.5, Part CS** of the Rules is to be so constructed as shown below.

Fig. CS3.5.1-1Rudder Stock of Type *B* and *C* Rudder



CS3.6 Rudder Plates, Rudder Frames and Rudder Main Pieces of Double Plate Rudders

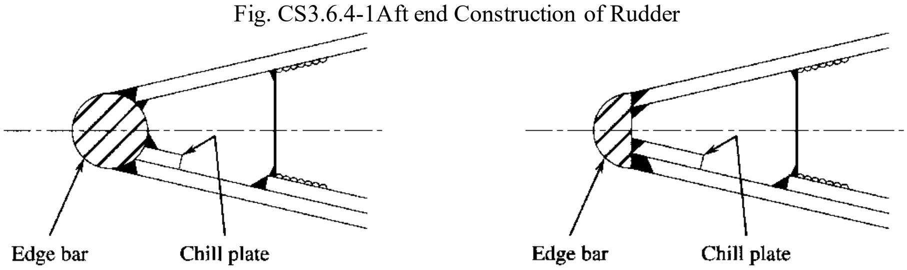
CS3.6.3 Rudder Main Pieces

Material factor K_m is to be for the lowest strength material among the materials used in the section considered.

CS3.6.4 Connections

In principle, edge bars are to be fitted to the aft end of the rudder. However, considering the size and form of the rudder, weldability, etc., edge bars and/or chill plates may be omitted. (*See* **Fig. CS3.6.4-1**)

Fig. CS3.6.4-1Aft end Construction of Rudder



CS3.9 Couplings between Rudder Stocks and Main Pieces

CS3.9.1 Horizontal Flange Couplings

1 Diameters of coupling bolts in Type *A* rudder

In the application of **3.9.1-1, Part CS** of the Rules, the diameter of the coupling bolt d_l in Type *A* rudder is to be determined in accordance with the requirements in **3.5.2, Part CS** of the Rules, assuming that the lower stock is cylindrical.

2 Locking device for nuts of coupling bolts

The nuts of coupling bolts are to have locking devices. They may be split pins.

3 In principle, rudder stock and flange are to be of monoblock construction. However, for ships less than 60 *m* in length, the rudder stock may be of a welded type where the stock is inserted into the flange and welded with edge preparation.

CS3.9.2 Vertical Flange Couplings

1 Diameter of coupling bolts in Type *A* rudder

In the application of **3.9.2-1, Part CS** of the Rules, the diameter of the coupling bolt d_l in Type *A* rudder is to be determined in accordance with **3.5.2, Part CS** of the Rules, assuming that the lower stock is cylindrical.

2 Locking devices for nuts of coupling bolts

The nuts of coupling bolts are to have locking devices. They may be split pins.

CS3.9.3 Cone Couplings with Key

1 General

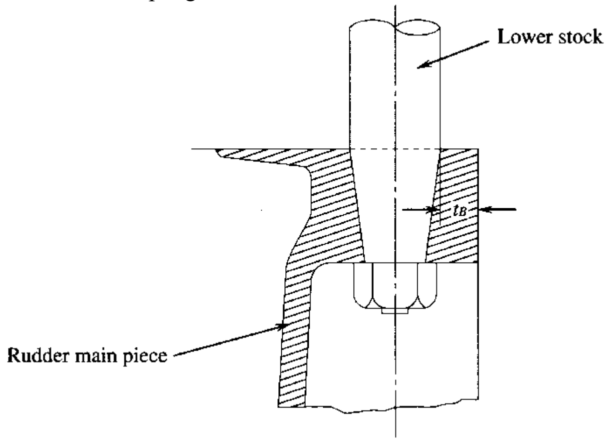
(1) The lower stock is to be securely connected to the rudder body with slugging nuts or hydraulic arrangements. Shipbuilders are to submit data on this connection to the Society.

(2) Special attention is to be paid to corrosion of the lower stock.

(3) The thickness t_B of the cast steel part of the rudder body (*See* **Fig. CS3.9.3-1**) is not to be less than 0.25 *times* the required diameter of the lower stock.

(4) In the application of **3.9.3-1** to **-3, Part CS** of the Rules, actual values are to be used for d_0, d_g and d_e.

Fig. CS3.9.3-1Coupling Between Lower Stock and Rudder Main Piece



2 In the application of **3.9.3-5, Part CS of the Rules** the scantlings of the key are as follows in cases where all rudder torque is considered to be transmitted by the key at the couplings.

(1) The shear area A_k of keys is not to be less than:

$$A_k = \frac{30T_R K_k}{d_k} \ (mm^2)$$

Where:

d_k: Rudder stock diameter (mm) at the mid-point of length of the key

K_k: Material factor for the key as given in **3.1.2, Part CS** of the Rules

T_R: Rudder torque obtained from **3.3, Part CS** of the Rules

(2) The abutting surface area A_c between the key and rudder stock or between the key and rudder body, respectively, is not to be less than:

$$A_c = \frac{10T_R K_{\max}}{d_k} \ (mm^2)$$

Where:

$K_{\max}$: The greater of the material factors (given in **3.1.2, Part CS** of the Rules) between the rudder stock and the key it is in contact with or the greater of the material factors between the rudder body and the key it is in contact with

d_k and T_R: As specified in **(1)**

CS3.9.4 Cone Couplings with Special Arrangements for Mounting and Dismounting the Couplings

The outer diameter of gudgeon (d_a) is recommended to be taken at the same plane in which the mean cone diameter (d_m).

CS3.10 Pintles

CS3.10.2 Construction of Pintles

1 Locking device for pintle nut

Split pins are not recommendable as the locking device for pintle nuts. Locking rings or other equivalent devices are to be used, as shown in **Fig. CS3.10.2-1**.

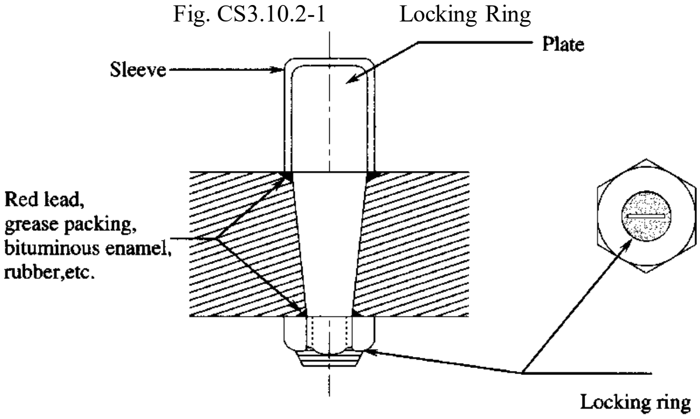
2 Preventing corrosion of pintles

To prevent corrosion of pintles, the end of the sleeve is to be filled with red lead, grease packing, bituminous enamel, rubber, etc. as shown in **Fig. CS3.10.2-1**.

3 Combination of pintle and rudder frame in monoblock

In ships exceeding 80 *m* in length, combining the pintle and rudder frame into a monoblock is not recommended.

Fig. CS3.10.2-1 Locking Ring



CS3.11 Bearings of Rudder Stocks and Pintles

CS3.11.1 Minimum Bearing Surface

1 Where a metal bush is used, the sleeve is to be of a different material from the bush (for example, sleeve of *BC*3 and bush of *BC*2).

2 "The type as deemed appropriate by the Society" stipulated in **Table CS3.3, Part CS** of the Rules means that approval is to be made in accordance with the requirements of **Chapter 5, Part 4 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

CS3.11.3 Bearing Clearances

Where a bush is non-metal, the standard bearing clearance is to be 1.5~2.0 *mm* in diameter.

CS3.12 Rudder Accessories

CS3.12.1 Rudder Carriers

1 Materials of rudder carriers and intermediate bearings

Rudder carriers and intermediate bearings are to be of steel. They are not to be of cast iron.

2 Thrust bearing of rudder carrier

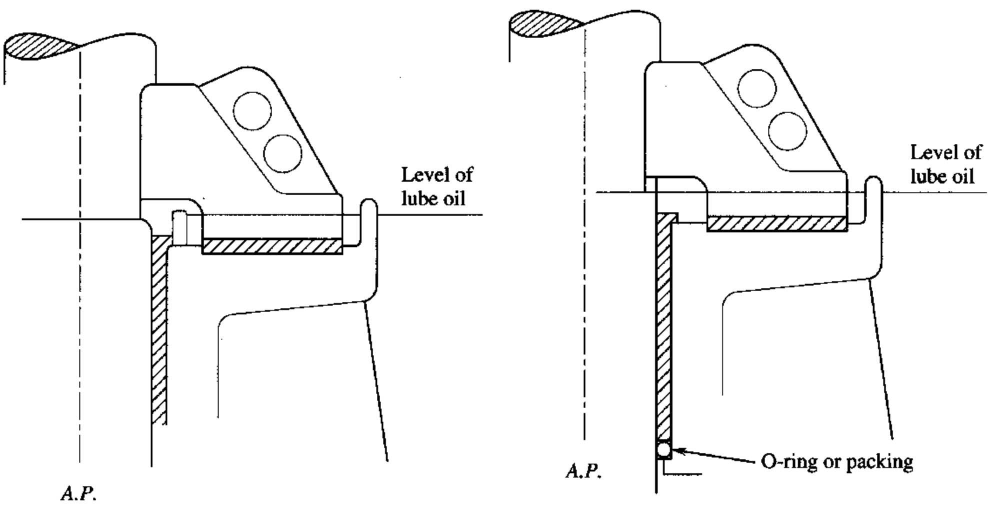
(1) The bearing is to be provided with a bearing disc made of bronze or other equivalent materials.

(2) The calculated bearing pressure is not to exceed 0.98 *MPa* as a standard. In calculating the weight of the rudder, its buoyancy is to be neglected.

(3) The bearing part is to be well lubricated by dripping oil, automatic grease feeding, or a similar method.

(4) The bearing is to be designed to be structurally below the level of lubricating oil at all times. (*See* **Fig.CS3.12.1-1**)

Fig. CS3.12.1-1 Rudder Carrier



3 Watertightness of rudder carrier part

(1) In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the waterline at scantling draught (without trim), two separate watertight seals or stuffing boxes are to be provided.

(2) It is recommended that the packing gland in the stuffing box have an appropriate clearance from the rudder stock corresponding to the position of the stuffing box. The standard clearance is to be 4 *mm* for the stuffing box provided at the neck or intermediate bearing, and 2 *mm* for the stuffing box at the upper stock bearing.

4 Assembly of rudder carriers

In split type rudder carriers, at least two bolts are to be used on each side of the rudder for assembly.

5 Installation of rudder carriers

(1) In ships exceeding 80 *m* in length, it is recommended that the rudder carrier is directly installed on the seat on the deck.

(2) A spigot type seat is not recommended to be installed on the deck.

(3) The hull construction in way of the rudder carrier is to be suitably reinforced.

6 Bolts securing rudder carriers and intermediate bearing

(1) At least one half of the bolts securing the rudder carrier and the intermediate bearing are to be reamer bolts. If stoppers for preventing the rudder carrier from moving are to be fitted on the deck, all bolts may be ordinary bolts. In using chocks as stoppers, they are to be carefully arranged so that they are not driven in, in the same direction. (*See* **Fig CS3.12.1-2**)

(2)

(a) In ships provided with electrohydraulic steering gears, the total sectional area of the bolts securing the rudder carriers or the bearing just under the tiller to the deck is not to be less than that obtained from the following formula:

$0.1d_u^2$ (mm^2)

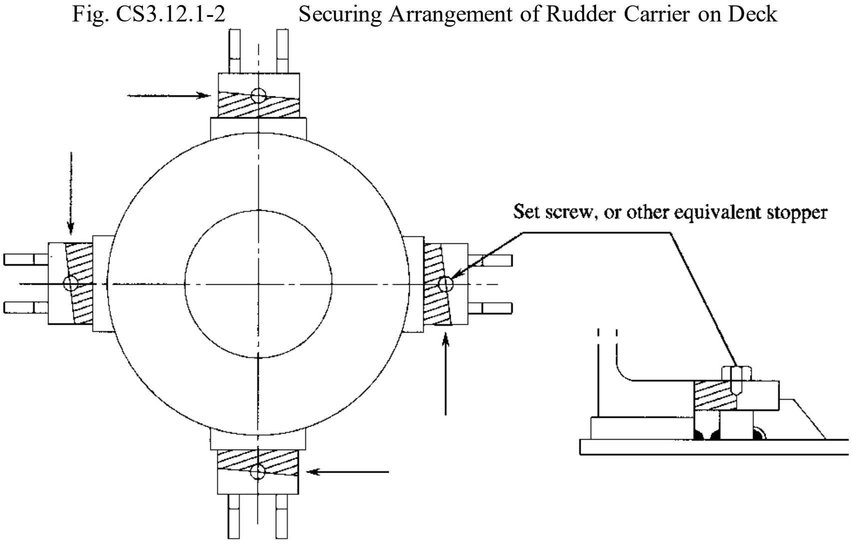
Where:

d_u: Required diameter of upper stock (mm)

(b) Where the arrangement of the steering gear is such that each of the two tiller arms is connected with an actuator and two actuators function simultaneously, or is of any other type where the rudder stock is free from horizontal force, the total sectional area of bolts securing the rudder carrier to the deck may be reduced to 60% of the area required in **(a)**.

(c) Where all the bolts securing the rudder carrier to the deck are reamer bolts, the total sectional area of bolts may be reduced to 80% of the area required by **(a)** and **(b)**.

Fig. CS3.12.1-2 Securing Arrangement of Rudder Carrier on Deck



C3.12.2 Prevention of Jumping

A 2 *mm* clearance between the jumping stopper and its contact surface is deemed as standard.

CS4 SUBDIVISIONS

CS4.1 General

CS4.1.1 Application

"Those ships specifically approved by the Society" refers to the following.

(1) Bulk carriers having freeboards of type *B*-60 or *B*-100 as specified in the requirements of **Part V** of the Rules; however, when carrying deck cargoes, the requirements of **Chapter 4, Part CS** of the Rules apply

(2) Special purpose ships complying with the requirements of *IMO Resolution MSC*.266(84)

CS4.1.2 Definitions

1 "Light service draught" stated in **4.1.2(4), Part CS** of the Rules corresponds, in general, to the ballast arrival condition with 10 % consumables.

2 "Deck or decks limiting the vertical extent of flooding" stated in **4.1.2(6), Part CS** of the Rules refers to the weather deck. However, when the ship has multiple decks above d_s + 12.5 (m) at the deepest subdivision draught, the deck just above d_s + 12.5 (m) is implied.

3 The wording "specifically accepted by the Society" stated in **4.1.2(13), Part CS** of the Rules means the carriage of timber and wood chip in cargo holds. Figures specified in **Table CS4.1.2** may be used as the permeability of compartment.

4 With respect to the provisions of **4.1.2(13), Part CS** of the Rules, the volume of spaces under consideration is to be taken as the moulded volume.

Table CS4.1.2 Permeability of Compartment Regarding Timber Cargo

Space for	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Timber cargo in holds	0.35	0.70	0.95
Wood chip cargo	0.60	0.70	0.95

CS4.2 Subdivision Index

CS4.2.1 Subdivision Index

1 If pipes, ducts or tunnels are provided within an assumed damaged compartment or group of compartments, they are to be arranged in such a way as to prevent flooding progressing to other compartments, or they are to be fitted with devices which can easily control the progress of flooding to other compartments. However, where the attained subdivision index takes into account flooding to other compartment through the pipes, ducts or tunnels, and satisfies the requirements in **4.2, Part CS** of the Rules, these requirements need not apply.

2 Notwithstanding the provisions of **-1** above, minor progressive flooding may be permitted if it is demonstrated that the effects of progressive flooding of other compartments through these pipes, ducts or tunnels can be easily controlled and the safety of the ship is not impaired. However, for ships up to L_f = 150 m the provision for allowing "minor progressive flooding" is to be limited to pipes penetrating a watertight subdivision with a total cross-sectional area of not more than 710 mm^2 between any two watertight compartments. For ships of L_f = 150 m and upwards the total cross-sectional area of pipes is not to exceed the cross-sectional area of one pipe with a diameter of L_f/5000 m.

3 Where penetrations for piping, ventilation, electrical cables, etc. are provided in bulkheads, decks and shells forming a compartment, the watertight integrity of the penetrations are to be at least equivalent to the parts they penetrate.

4 With the same intent as wing tanks, the summation of the attained index A is to reflect effects caused by all watertight bulkheads and flooding boundaries within the damaged zone. It is not correct to assume damage only to one half of the ship's breadth (B') and ignore changes in subdivision that would reflect lesser contributions.

5 In the forward and aft ends of the ship where the sectional breadth is less than the ship's breadth (B') specified in **4.1.2(11), Part CS** of the Rules, transverse damage penetration may extend beyond the centreline bulkhead.

6 Where, at the extreme ends of the ship, the subdivision exceeds the waterline at the deepest subdivision draught, the damage penetration b or $B'/2$ is to be taken from centreline. **Fig. CS4.2.1** illustrates the shape of the $B'/2$ line.

7 Where longitudinal corrugated bulkheads are fitted in wing compartments or on the centreline, they may be treated as equivalent plane bulkheads provided the corrugation depth is of the same order as the stiffening structure. The same principle may also be applied to transverse corrugated bulkheads.

8 Pipes and valves directly adjacent or situated as close as practicable to a bulkhead or to a deck can be considered to be part of the bulkhead or deck, provided the separation distance on either side of the bulkhead or deck is of the same order as the bulkhead or deck stiffening structure. The same applies for small recesses, drain wells, etc. In no case is the separation distance on either side of the bulkhead or deck to be more than 450 *mm* measured from the valve's near end to the bulkhead or deck. An example is shown in **Fig. CS4.2.2**.

9 In setting the trim and G_0M used to calculate the subdivision index, reference is also to be made to **1.3.10-11** and **1.3.10-12, Annex U1.2.1 "GUIDANCE FOR STABILITY INFORMATION FOR MASTER", Part U of the Guidance**.

Fig. CS4.2.1

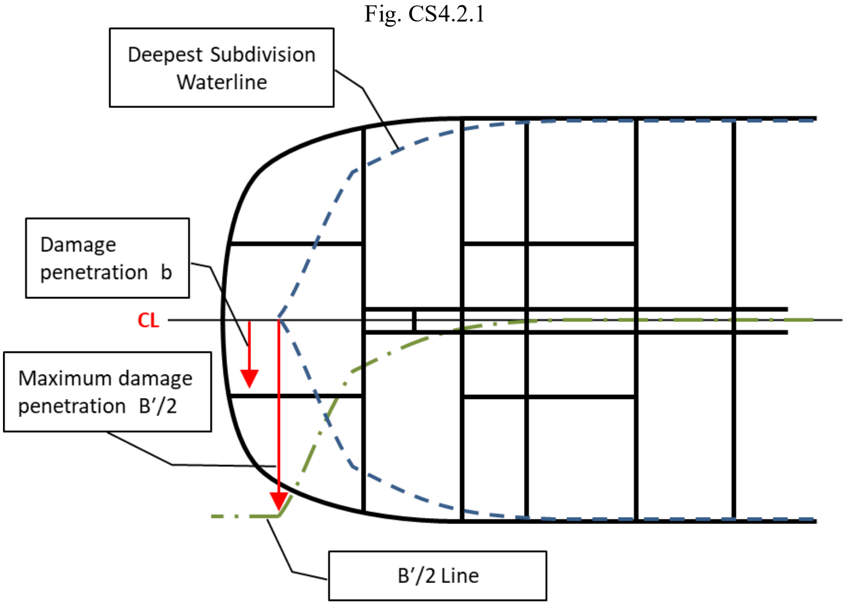
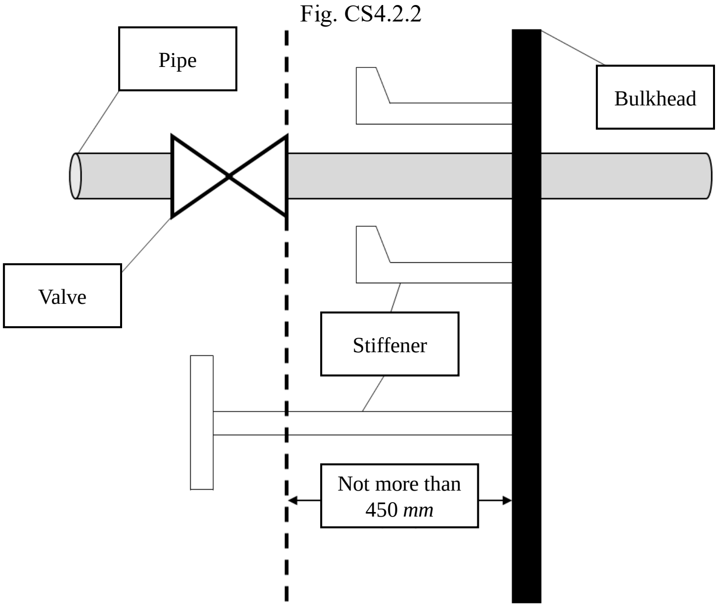


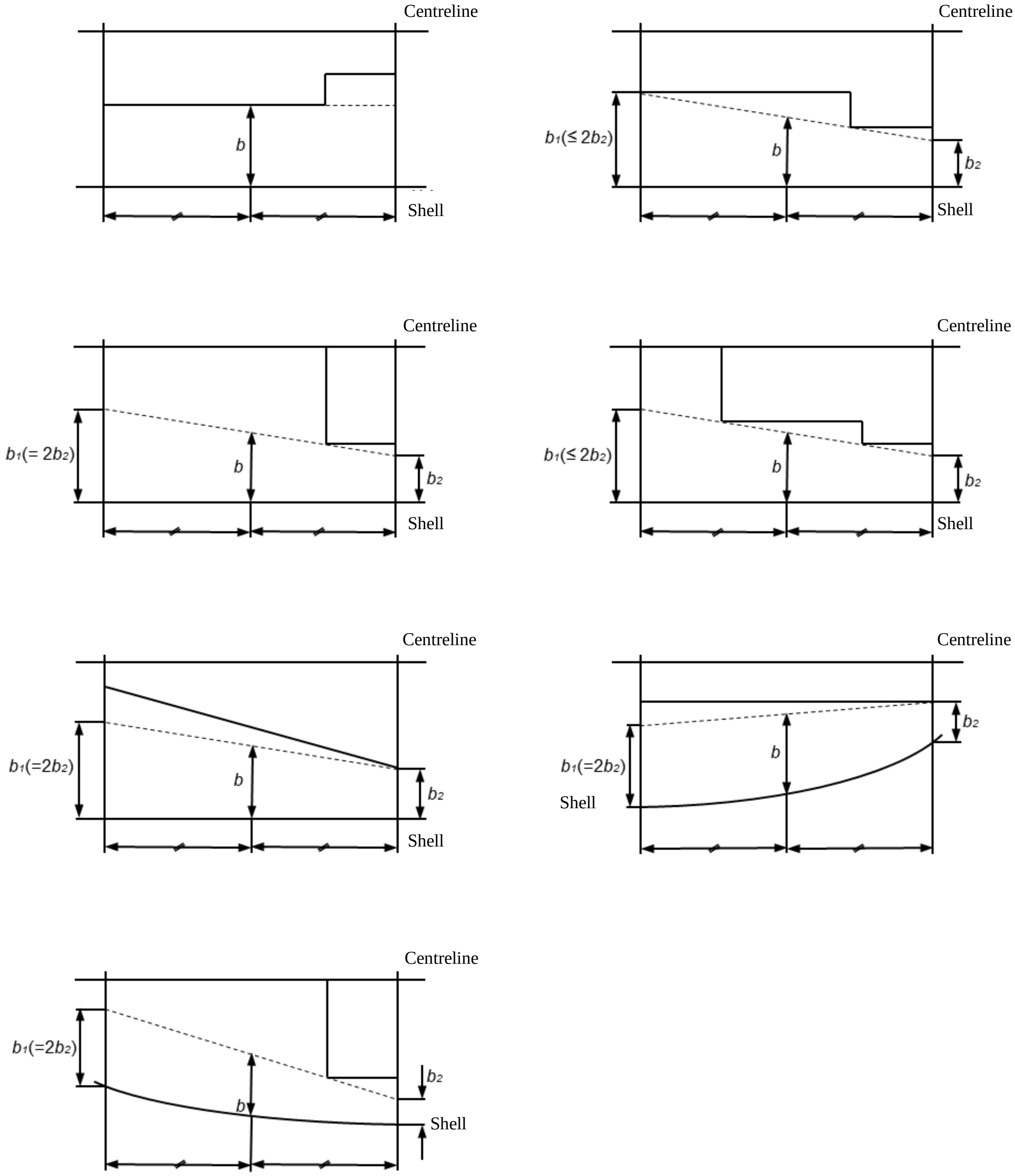
Fig. CS4.2.2



CS4.2.2 Compartment Flooding Probability (p_i)

In application of the requirement of **4.2.2-1, Part CS** of the Rules, in case where the longitudinal bulkhead is not paralleled to the side shell plating, the assumed vertical plane which is considered in the determination of transverse distance (b) between longitudinal bulkhead and side shell plating is to be refer to a example specified in **Fig.CS4.2.3**.

Fig. CS4.2.3 Examples of Assumed Vertical Plane (In case of Single Damage Zone)



CS4.2.3 Probability of Survival (s_i)

1 Openings (e.g., access openings provided in the end bulkhead of the superstructure and cargo hatchways), air pipes, and ventilators which are provided only with the weathertight closing apparatus specified in **Part CS** of the Rules are to be treated as allowing progress of flooding when the water line at the final equilibrium state immerses their lower edge.

2 In applying θ_v specified in **4.2.3-1, Part CS of the Rules**, an "opening incapable of being closed weathertight" includes ventilators provided with weathertight closing appliances in accordance with the requirements of **21.6.5-2, Part CS of the Rules** that for operational reasons have to remain open to supply air to the engine room, emergency generator room or closed ro-ro and vehicle spaces (if the same is considered buoyant in the stability calculation or protecting openings leading below) for the effective operation of the ship. Where it is not technically feasible to treat some closed ro-ro and vehicle space ventilators as unprotected openings, an alternative arrangement that provides an equivalent level of safety may be used provided that it is deemed appropriate by the Administration.

3 The calculation of the probability of survival (s_i) in **4.2.3-10, Part CS of the Rules** is to be treated as follows.

(1) Where the buoyancy of the timber deck cargo is taken into account, the cargo is to be in compliance with the following **(a)** to **(d)**:

(a) The timber deck cargo is to be stowed in accordance with the requirements of **Section 2.9, Part A** of the *Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011* (*IMO* resolution *A*.1048(27)).

(b) The timber deck cargo is to be secured by lashings, uprights or both.

(c) Lashings and uprights are to comply with the requirements of **Section 2.10, Part A** of the *Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011* (*IMO* resolution *A*.1048(27)).

(d) The height and extent of the timber deck cargo is to be in accordance with **Section 3.3.2** of **Chapter 3, Part A** of the *International Code on Intact Stability, 2008 (2008 IS Code)* and is to be at least stowed to the standard height of one superstructure.

(2) The permeability of the timber deck cargo is not to be less than 25 % of the volume occupied by the cargo up to one standard superstructure height.

(3) When the buoyancy of any timber deck cargo is taken into account, the timber deck cargo in way of a damaged zone is deemed ineffective to all areas in an athwartships direction. However, when the vertical extent of the damage stops at the upper deck and the coefficient (v_m) from **4.2.3-4, Part CS** of the Rules is used in the calculations, the buoyancy of the timber deck cargo may be taken into account in accordance with **(2)** above even if it is directly above the damaged area.

4 Tanks and compartments taking part in such equalization is to be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.

5 In applying the requirements specified in **4.2.3-9(2), Part CS of the Rules**, with respect to equalization devices, reference is to be made to the *IMO Res. MSC*.362(92) *"Revised Recommendation on a standard method for evaluating cross-flooding arrangements"*, as amended.

6 If the final waterline immerses the lower edge of any opening through which progressive flooding takes place, the factor "*s*" may be recalculated taking such flooding into account. However, in this case the *s* value is also to be calculated without taking into account progressive flooding and corresponding opening. The smallest *s* value is to be retained for the contribution to the attained index.

CS4.3 Openings

CS4.3.1 Internal Openings

1 "Watertight" stated in **4.3.1-1, Part CS** of the Rules means watertight integrity that is sufficient against a water head corresponding to the opening in question at the final equilibrium state and intermediate waterline.

2 With respect to the provisions of **4.3.1-2, Part CS** of the Rules, watertight closing appliances are categorized as in the following **(1)** to **(3)** corresponding to their purpose and frequency of use.

(1) Watertight closing appliances which are to be *permanently closed* at sea:
Such appliances are open in port and closed before the ship leaves port. The time of opening/closing such doors is to be recorded in the log-book.

(2) Watertight closing appliances which are to be *normally closed* at sea:
Such appliances are kept closed at sea but may be used if authorized by the officer of the watch and to be closed again after use.

(3) Watertight closing appliances which are *used* at sea:
Such appliances are used regularly and may be left open provided they are ready to be immediately closed.

3 General requirements of **4.3.1-2, Part CS** of the Rules are shown in **Table CS4.3.1-1**.

4 Details of functions, specifications, etc. for the power, controls, indicators, alarms, notices for watertight closing appliances specified in **4.3.1-2, Part CS** of the Rules are to be in accordance with **13.3, Part CS** of the Rules.

5 With respect to the provisions of **4.3.1-2, Part CS** of the Rules, watertight closing appliances above the bulkhead deck are also to comply with the requirements for doors provided for means of escape specified in **Chapter 13, Part R** of the Rules.

CS4.3.2 External Openings

1 General requirements of closing appliances specified in **4.3.2, Part CS** of the Rules are show in **Table CS4.3.1-2**.

2 Details of indicators for the watertight closing appliances specified in **4.3.2, Part CS** of the Rules are to be in accordance with **13.3.5, Part CS** of the Rules.

3 "Bridge" stated in **4.3.2-2, Part CS** of the Rules means the place where the watch officer is always present and normally implies the navigation bridge deckhouse.

Table CS4.3.1-1 Requirements for Closing Devices for Internal Openings

Position relative to bulkhead or freeboard deck	Referenced requirement in **Part CS** of the Rules	Frequency of use	Type of closing appliance	Remote closure	Open/close indicators	Audible or visual alarms	Notices	Notes
Below	4.3.1-2(2), 13.3.4-2 13.3.5, 13.3.6	Used	POS	Yes	Yes	Yes (Local)	No	---
	4.3.1-2(3), 13.3.5-1 13.3.8-1	Norm. Closed	S or H	No	Yes	No	Yes	*1, 6
	4.3.1-2(4), 13.3.4-3 13.3.8-2	Perm. Closed (cargo spaces)	S or H	Prohibited	No	No	Yes	*3, 4, 7
	4.3.1-2(5), 13.3.8-2	Perm. Closed (others)						
At or above	4.3.1-2(2), 13.3.4-2 13.3.5, 13.3.6	Used	POS	Yes	Yes	Yes (Local)	No	*2, 5
	4.3.1-2(3), 13.3.5-1 13.3.8-1	Norm. Closed	S or H	No	Yes	No	Yes	*1, 6
	4.3.1-2(4), 13.3.8-2	Perm. Closed	S or H	Prohibited	No	No	Yes	*3, 4, 7

Notes:

*1 : If hinged, this door is to be of single-action type.

*2 : Under the "International Convention on Load Lines, 1966", doors separating a main machinery space from a steering gear compartment may be hinged single-action types provided the lower sill of such doors is above the Summer Load Line and the doors remain closed at sea whilst not in use.

*3 : The time of opening such doors in port and closing them before the ship leaves port is to be entered into the logbook in the case of doors in watertight bulkheads subdividing cargo spaces.

*4 : Doors are to be fitted with devices which prevent unauthorized opening.

*5 : Under *MARPOL*, hinged watertight doors may be acceptable in watertight bulkheads of the superstructure.

*6 : Notices are to state "Kept closed at sea".

*7 : Notices are to state "Not to be opened at sea".

Table CS4.3.1-2 Requirements for Closing Devices for External Openings

Position relative to bulkhead or freeboard deck	Referenced requirement in Part CS of the Rules	Frequency of use	Type of closing appliance	Remote closure	Open/close indicators	Audible or visual alarms	Notices	Notes
Below	4.3.2-2, 4.3.2-3 13.3.8-2	Perm. Closed	S or H	No	Yes	No	Yes	*2, 3, 5
At or above	13.3.5-1, 13.3.8-1	Norm. Closed	S or H	No	Yes	No	Yes	*1, 4
	4.3.2-2, 13.3.8-2	Perm. Closed	S or H	No	Yes	No	Yes	*2, 3, 5

Notes:

*1 : If hinged, this door is to be of single-action type.

*2 : The time of opening such doors in port and closing them before the ship leaves port is to be entered into the logbook in the case of doors in watertight bulkheads subdividing cargo spaces.

*3 : Doors are to be fitted with devices which prevent unauthorized opening.

*4 : Notices are to state "Kept closed at sea".

*5 : Notices are to state "Not to be opened at sea".

CS5 SINGLE BOTTOMS

CS5.4 Floor Plates

CS5.4.3 Scantlings

In ships which have L and C_b not more than 150 m and 0.7 respectively, and $V/\sqrt{L}$ not less than 1.4, it is recommended that the face plates of floors in way of strengthened bottom forward required in **CS6.9.1-2(1)** are to be plated. The thickness of floors is to comply with the requirements in **CS6.9.1-2(3)**.

CS6 DOUBLE BOTTOMS

CS6.1 General

CS6.1.1 Application

1 "Ships deemed by the Society to not require a double bottom for special reasons" stipulated in **6.1.1-2, Part CS** of the Rules refer to the following.

(1) Ships complying with **Part N** or **Part S** of the Rules

(2) Ships complying with **3.2.2, Part 3 of the Rules for Marine Pollution Prevention Systems**

2 "Deemed appropriate by the Society" stipulated in 6.1.1-2, Part CS of the Rules refers to cases where the safety of the ship can be ascertained through flooding calculations.

3 Application of requirements related to the omission of double bottoms or unusual bottom arrangements in **6.1.1-3, Part CS** of the Rules is to be in accordance with following **(1)** and **(2)**. For example, arrangements in which parts of the double bottom do not extended for the full width of the ship or in which the inner bottom is located higher than the partial subdivision draught (d_p) defined in **4.1.2(5), Part CS** of the Rules are to be considered to be unusual bottom arrangements.

(1) When it is assumed that such spaces are subject to a bottom damage, compartments are to be arranged to demonstrate that the factor s_i, when calculated in accordance with **4.2.3, Part CS** of the Rules, is not less than 1 for those service conditions which are the three loading conditions used to calculate the Attained Subdivision Index (A) specified in **4.2.1-2, Part CS** of the Rules. Assumed extent of damage is to be in accordance with following **Table CS6.1.1-1**. If any damage of a lesser extent than the maximum damage specified in **Table CS6.1.1-1** would result in a more severe condition, such damage is to be considered. However, for ships less than 80 m in length for freeboard (L_f), it may be assumed that the damage will only occur between the transverse watertight bulkheads.

(2) Flooding of such spaces is not to render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship.

Table CS6.1.1-1 Assumed Extent of Damage

	For 0.3L from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	$1/3L_f^{2/3}$ or 14.5m, whichever is less	$1/3L_f^{2/3}$ or 14.5m, whichever is less
Transverse extent	B'/6 or 10m, whichever is less	B'/6 or 5m, whichever is less
Vertical extent, measured from the keel line	B'/20, to be taken not less than 0.76 m and not more than 2 m	B'/20, to be taken not less than 0.76 m and not more than 2 m

Notes:

1. Keel line is to be in accordance with **2.1.48, Part A of the Rules**.
2. Ship breadth (B') is to be in accordance with **4.1.2(11), Part CS of the Rules**.

CS6.1.3 Drainage

1 In the application of **6.1.3-1, Part CS** of the Rules, the requirements in the following **(1)** to **(3)** are to be complied with where bilge tanks are provided instead of bilge wells.

(1) Bilge tanks are to have sufficient strength as deep tanks as required in **Chapter 14, Part CS** of the Rules.

(2) Drain pipes leading to bilge tanks are to comply with the requirement in **D13.5.8**.

(3) Bilge tanks are to be provided with manholes and covers for the purpose of conducting internal inspections easily.

2 "As deemed appropriate by the Society" stipulated in **6.1.3-2, Part CS** of the Rules means that the requirements specified in

CS6.1.1-3(1) are satisfied.

3 "Protection equivalent to that afforded by a double bottom complying with this chapter" stipulated in 6.1.3-3, Part CS of the Rules means that the requirements specified in CS6.1.1-3(1) are satisfied. However, for ships not less than 80 *m* in length for freeboard (L_f), wells for lubricating oil below main engines may protrude into the double bottom below the boundary line defined by the distance h (h is specified in 6.1.1-1, Part CS of the Rules) provided that the vertical distance between the well bottom and a plane coinciding with the keel line is not less than $0.5h$ or 500 *mm*, whichever is greater.

CS6.6 Longitudinals

CS6.6.2 Scantlings

1 For longitudinal stiffeners in double bottoms, where both ends of those stiffeners are fixed to vertical stiffeners on solid floors, horizontal stiffeners on vertical webs or struts, the section modulus required for those stiffeners may be multiplied by the value obtained from the following formula:

$$\left(1-\frac{a}{l}\right)^2\left(1-\frac{b}{l}\right)$$

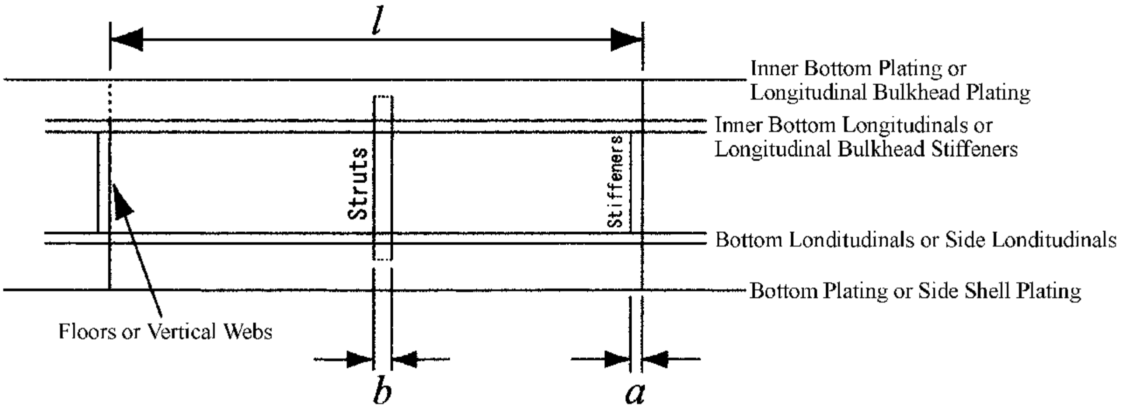
l : Distance (m) between floors or vertical webs

a : Width (m) of stiffeners of floors or vertical webs (a is zero if the stiffeners are not secured to longitudinals or other stiffeners by means of a lug connection)

b : Width of struts (m)

(*See* Fig. CS6.6.2-1)

Fig. CS6.6.2-1



CS6.7 Inner Bottom Plating and Margin Plates

CS6.7.1 Thickness of Inner Bottom Plating

1 Where the height of the centre girder is less than $B/16$, the thicknesses of the inner bottom plating and bottom shell plating are to be increased so that the moment of inertia of the double bottom obtained from the following formula may be equivalent to that corresponding to when the centre girder has the required height.

$$I = 1.23\frac{t_1 t_2}{t_1 + t_2}d_0^2$$

Where:

d_0: Height (m) of centre girder

t_1: Thickness (mm) of bottom shell plating

t_2: Thickness (mm) of inner bottom plating

2 Where fork-lift trucks are used for handling cargoes, CS17.3.5 is to be applied for determining the thickness of the inner bottom plating.

CS6.9 Construction and Strengthening of the Bottom Forward

CS6.9.1 Application

1 Here, "ballast condition" means the ordinary ballast condition where only ballast tanks such as clean ballast tanks, segregated ballast tanks and ballast holds are ballasted. This ballast condition excludes exceptional cases where cargo tanks are ballasted in heavy weather conditions to ensure the safety of the ship.

2 In ships of which C_b is not more than 0.7 and $V/\sqrt{L}$ is not less than 1.4, the construction of the bottom forward is to be as required in the following **(1)**, **(2)** and **(3)**.

(1) Construction

The construction of the strengthened bottom forward is to be in accordance with **6.9.3, Part CS** of the Rules. However, the vertical stiffeners for the solid floors specified in **6.9.3-3, Part CS** of the Rules are to be provided on all shell stiffeners. Where the bottom longitudinals or longitudinal shell stiffeners are extended through the solid floors, slots are to be reinforced with collar plates.

(2) Scantlings of longitudinal shell stiffeners or bottom longitudinals

(a) In ships having a bow draught of not more than $0.025L$ in ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is not to be less than that obtained from the following formula:

$$0.53P\lambda l^2 \ (cm^3)$$

Where:

l : Spacing (m) of solid floors

λ : $0.774l$.

However, where the spacing of longitudinal shell stiffeners or bottom longitudinals is not more than $0.774l$, λ is to be taken as the spacing (m).

P : Slamming impact pressure (kPa) obtained from the following formula:

$$2.48\frac{LC_1C_2C_3}{\beta} \ (kPa)$$

C_1: Coefficient given in **Table CS6.9.1-1**. For intermediate values of $V/\sqrt{L}$, C_1 is to be obtained by linear interpolation.

C_2: Coefficient obtained from following formula:

Where $\frac{V}{\sqrt{L}}$ is 1.0 and under: 0.4

Where $\frac{V}{\sqrt{L}}$ is over 1.0, but less than 1.3: $0.667\frac{V}{\sqrt{L}} - 0.267$

Where $\frac{V}{\sqrt{L}}$ is 1.3 and over: $1.5\frac{V}{\sqrt{L}} - 1.35$

β: Slope of the ship's bottom obtained from the following formula, but C_2/β need not be taken as greater than 11.43:

$$\frac{0.0025L}{b}$$

b : Horizontal distance (m) measured at the station $0.2L$ from the stem, from the centre line of the ship to the intersection of the horizontal line $0.0025L$ above the top of the keel with the shell plating (*See* **Fig. CS6.9.1-1**)

C_3: Coefficient obtained from the following formula:

$$C_3 = 1.9 - 0.9\left(\frac{d_f}{0.025L}\right)$$

Where:

d_f: Minimum bow draught in ballast condition

(b) In ships having a bow draught of more than $0.025L$ but less than $0.037L$ in ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is to be obtained by linear interpolation from the values given by the requirements in **(a)** and **6.6, Part CS** of the Rules.

(3) Thickness of solid floors

The thickness of solid floors in way of the strengthened bottom forward is obtained from the following requirements **(a)** and **(b)**, whichever is greater:

(a) The thickness obtained from the following formula.

$$\frac{PSb_1}{196(b_1-d_1)}+2.5\ (mm)$$

P : Slamming impact pressure given by **(2)(a)**. In ships having a bow draught of more than $0.025L$ but less than $0.037L$ in ballast condition, this requirement is to be applied using the actual bow draught in ballast condition.

S : Spacing (m) of solid floors

b_1: Breadth (m) of solid floor panel between the midpoints of the spaces on either side of a bottom longitudinal (excluding longitudinal shell stiffeners provided in between bottom longitudinals)

(*See* **Fig. CS6.9.1-2**)

d_1: Total breadth (m) of openings (lightening holes, slots, etc.) at the level of the floor in question ($d_1=d_2+d_3$) Where, the openings are reinforced with doubling plates, the sectional area may be considered.

(b) The thickness obtained from the following formula.

$$1.1\cdot\sqrt[3]{PSb_2{}^2}+2.5\ (mm)$$

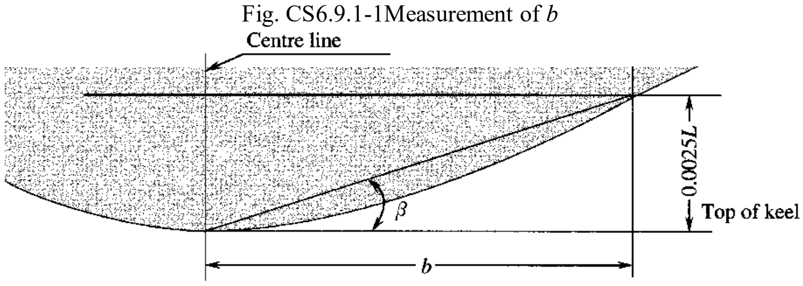
P and S: As specified in **(a)**.

b_2: Spacing (m) of bottom longitudinals (*See* **Fig. CS6.9.1-2**)

Table CS6.9.1-1 Value of C_1

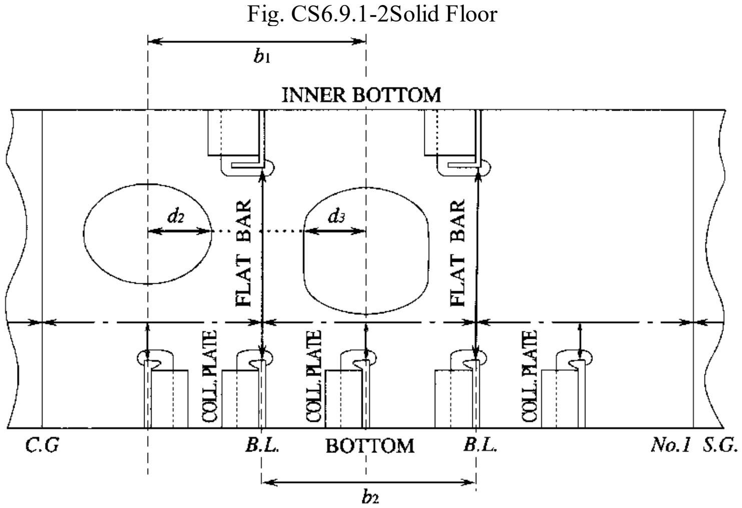
$V/\sqrt{L}$	1.4	1.5	1.6	1.7	1.8
C_1	0.31	0.33	0.36	0.38	0.40

Fig. CS6.9.1-1Measurement of b



(Hull section at the station $0.2L$ from the stem)

Fig. CS6.9.1-2Solid Floor



3 In way of the strengthened bottom forward, structural arrangements other than those specified in 6.9.3, Part CS of the Rules may be adopted subject to the following **(1)** to **(3)**.

(1) Solid floors of a longitudinal stiffened system and girders in a transverse stiffened system are to comply with the provisions of CS6.9.1-2(3). The slamming impact pressure P acting on the solid floors of a longitudinal stiffened system may be corrected by multiplying the coefficient C_9 specified in **(3)** below.

(2) The thickness of solid floors and girders is to be in accordance with the value obtained by the following.

$$t_1 = K \cdot \frac{C_8 \cdot P \cdot S \cdot l}{226 \cdot (d_0 - d_1)} + 2.5 \ (mm)$$

K: As specified in 1.2.1-2(2) of **Annex CS1.3.1-1 "GUIDANCE FOR HULL CONSTRUCTION CONTAINING HIGH TENSILE STEEL MEMBERS"**

P: The applicable slamming impact pressure as specified in 6.9.4-1, Part CS of the Rules, or CS6.9.1-2.

In ships having a bow draught of more than $0.025L'$ but less than $0.037L'$ in ballast condition, the slamming impact pressure of when the bow draught is $0.037L'$ is to be obtained by linear interpolation from the following formula. The slamming impact pressure is not to be less than the value obtained by the following formula.

$P = 1.015L \quad (kPa)$

C_8: As given by the following formula

This value is not to be less than 0.1 and not to be greater than 1.

$$C_8 = \frac{3}{A}$$

A: Area (m^2) considered in the strength examination, as given by the following formula

$A = S \times l$

S: Spacing (m) of solid floors (or girders) when solid floors (or girders) are under consideration

l: Spacing (m) of girders (or solid floors) when solid floors (or girders) are under consideration

d_0: Depth (m) of floors or girders at the considered position

d_1: Depth (m) of openings in the floors or girders at the considered position

(3) In the calculation of the section modulus of longitudinal shell stiffeners and bottom longitudinals, the slamming impact pressure P may be corrected by multiplying by the coefficient C_9 as given by the following formula. The coefficient C_9 is not to be less than 0.1 and not to be greater than 1.

$$C_9 = \frac{3}{l}$$

l: As given in 6.9.4-1, Part CS of the Rules

CS6.9.2 Strengthened Bottom Forward

In ships of which C_b is less than 0.7 and the bow draught is less than $0.025L$ in ballast condition, the area of the strengthened bottom forward of the ship is to be expanded as follows. However, ships that carry a certain amount of cargo regularly such as Container Ships need not comply.

(1) The after end of the strengthened area is to be extended the distance a afterwards from the position required in 6.9.2-1 of Part CS.

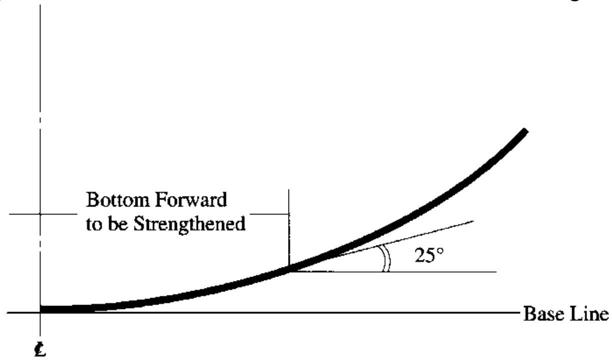
$a = 0 \quad (C_b = 0.7)$

$a = 0.05L \quad (C_b \leq 0.6)$

For intermediate values of C_b, a is to be obtained by linear interpolation.

(2) In addition to **(1)** above, bottom areas whose tangential slope to the base line is less than 25 *degrees* are required to be strengthened. (*See* Fig. CS6.9.2-1)

Fig. CS6.9.2-1Transverse Area of Bottom Forward to be Strengthened



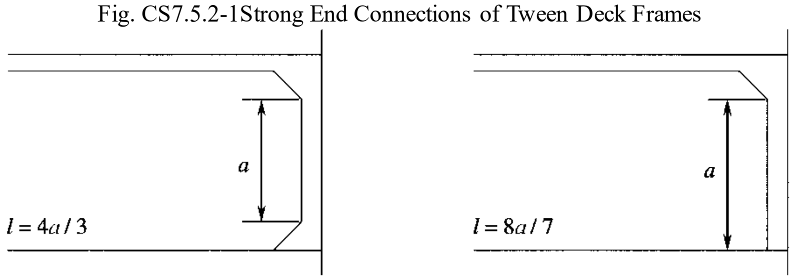
CS7 FRAMES

CS7.5 Tween Deck Frames

CS7.5.2 Scantlings of Tween Deck Frames

Where ends of tween deck frames are connected with brackets that have an arm length longer than $l/8$, the requirements of **7.5.2, Part CS** of the Rules may be applied in the manner shown in **Fig. CS7.5.2-1**.

Fig. CS7.5.2-1Strong End Connections of Tween Deck Frames



CS7.5.3 Special Precautions Regarding Tween Deck Frames

In ships with multiple decks such as pure car carriers that have freeboards shorter than the length given in **Table CS7.5.3-1**, the tween deck frames above the freeboard deck are to be generally reinforced according to the ship's length as follows.

(1) Range of reinforcement is at least up to the tween deck frames of the first tier above the freeboard deck.

(2) The section modulus of tween deck frames is to be determined applying the requirements of **7.5.2-1, Part CS** of the Rules. However, the coefficient C is to be obtained from **Table CS7.5.3-2**, according to the description of the tween deck frames. The section modulus of parts forward of the collision bulkhead and abaft the after peak bulkhead is not to be less than the values determined applying the requirements in **7.6.1** and **7.6.3, Part CS** of the Rules.

Table CS7.5.3-1 Standard Value of Freeboard

Length of Ship: L (m)	$75>L$	$75 \leq L < 90$
Freeboard (m)	0.36	0.40

Table CS7.5.3-2 Coefficient C

Description of tween deck frames	C
Superstructure frames for $0.125L$ from fore end and cant frames at stern	0.89
Superstructure frames for $0.125L$ from aft end	0.74
Superstructure frames excluding above	0.54

CS8 CANTILEVER BEAM CONSTRUCTION

CS8.3 Connection of Cantilever Beams to Web Frames

1 To prevent the buckling of end brackets of cantilever beams connected to web frames, stiffeners are to be fitted to the brackets, with suitable spacing, in order to keep their panels small as shown in **Fig. CS8.3-1**.

2 Within the range of 1/2 of the throat depth of the end bracket from the side of the face plate, stiffeners such as inverted angles are to be arranged in the direction of compression at the spacing obtained from the following formula. This spacing is deemed as the standard.

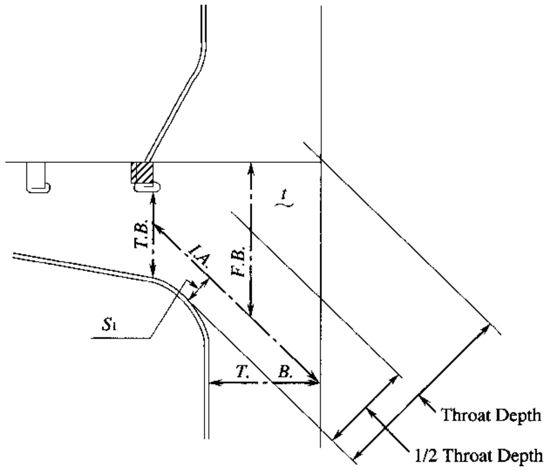
$$S_1 = 35(t - 2.5)$$

Where:

S_1: Spacing (mm) of stiffeners (*See* **Fig. CS8.3-1**)

t : Thickness (mm) of bracket

Fig. CS8.3-1 Reinforcement of Brackets



CS9 ARRANGEMENTS TO RESIST PANTING

CS9.1 General

CS9.1.2 Swash Plates

The scantlings of swash plates in fore and aft peak tanks used as deep tanks are to comply with **9.2.2-5, Part CS** of the Rules.

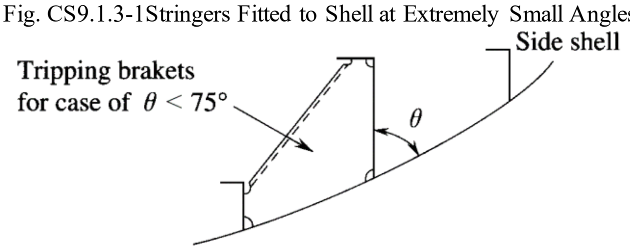
CS9.1.3 Stringers Fitted to Shell at Extremely Small Angles

Where the angle between the web of stringers and the shell plating is smaller than 75°, the stringer is to be treated as follows unless approved otherwise by the Society (*See* **Fig. CS9.1.3-1**). In general, even where stringers and girders attach to the shell at an angle, the actual section modulus is to be calculated against a neutral axis parallel to the shell plating.

(1) Face plates are to be fitted on the side of open bevels.

(2) Tripping brackets are to be fitted spaced suitably.

Fig. CS9.1.3-1Stringers Fitted to Shell at Extremely Small Angles

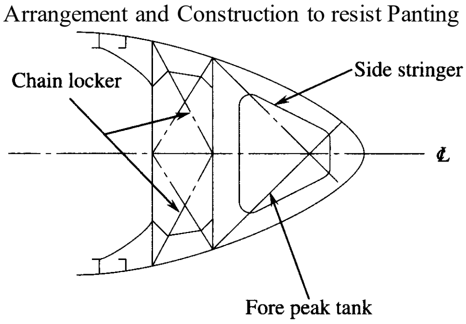


CS9.2 Arrangements to Resist Panting Forward of Collision Bulkhead

CS9.2.1 Arrangement and Construction

Where bottom plates of chain lockers, which are located forward collision bulkhead and reach side shell, are not situated in the level of side stringer, horizontal girders are recommended to be fitted in chain lockers at the stringer level. (*See* **Fig. CS9.2.1-1**)

Fig. CS9.2.1-1 Arrangement and Construction to resist Panting in way of Chain Locker



CS10 BEAMS

CS10.1 General

CS10.1.2 Connections of Ends of Beams

1 The connection method of the ends of longitudinal beams shown in **Fig. CS10.1.2-1** is standard.

2 The connection method of transverse beams by means of brackets shown in **Fig. CS10.1.2-2** is standard.

Fig. CS10.1.2-1

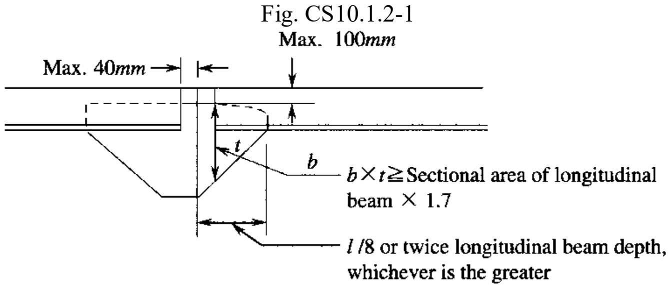
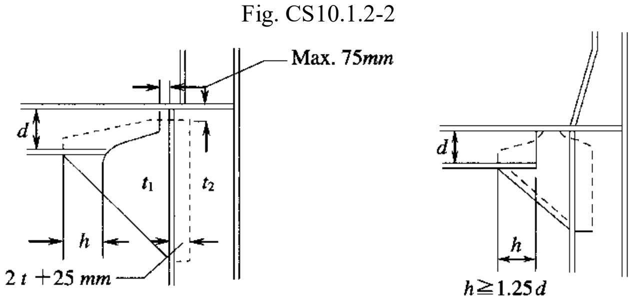


Fig. CS10.1.2-2



$h \geqq 1.5 \times$ width of free flange for inverted angles
$h \geqq 75\ mm$ for bulb plates
$t = t_1$ or t_2, whichever is the smaller

CS10.2 Longitudinal Beams

CS10.2.3 Section Modulus of Longitudinal Beams

The section modulus of longitudinal beams outside the line of hatchway openings of the strength deck fore and aft of the midship part may be determined by interpolation between the requirements of **10.2.3-1** and **10.2.3-2, Part CS** of the Rules. Interpolation may be performed at the middle of each building block in the direction of the ship's length. However, where the length of the block is over 15 *metres*, the block is to be subdivided into appropriate lengths.

CS10.3 Transverse Beams

CS10.3.2 Proportion

Where the span/depth ratio of transverse beams exceeds 30 in strength decks or 40 in effective decks and superstructure decks, the section moduli of these beams are to be increased by the corresponding ratios.

CS10.7 Deck Beams Supporting Vehicles

CS10.7.1 Section Modulus of Beams

1 The section modulus of beams of decks loaded with wheeled vehicles (hereinafter referred to as "car decks") is not to be less

than that obtained from the following formula. Where the span length or moment of inertia changes along the continuous beam, the scantlings of the beam are to be determined by direct strength calculation as specified in **-2**.

$C_1 C_2 M$ (cm^3)

Where:

C_1: Coefficient determined as follows:

C_1: 1.0 for $b/S \leq 0.8$

C_1: 1.25-0.31 b/S for $b/S > 0.8$

Where:

S : Beam spacing (m)

b : Length (m) of wheel print measured at right angle to beams (*See* **Fig. CS10.7.1-1**)

For vehicles with ordinary pneumatic tires, values in **Table CS10.7.1-1** may be used.

C_2: Coefficient determined from **Table CS10.7.1-2**

M : M_1, M_2 and M_{3j} obtained from the following formulae, whichever is the greatest ($kN \cdot m$):

$$M_1 = \frac{1}{15}\left[\sum_{i=1}^{N_I} 4P_{Ii}\alpha_{Ii}\left\{1-\left(\frac{\alpha_{Ii}}{l}\right)^2\right\} + \sum_{j=1}^{N_{II}} P_{IIj}\alpha_{IIj}\left(1-\frac{\alpha_{IIj}}{l}\right)\left(7-5\frac{\alpha_{IIj}}{l}\right) - \sum_{k=1}^{N_{III}} P_{IIIk}(l-\alpha_{IIIk})\left\{1-\left(\frac{l-\alpha_{IIIk}}{l}\right)^2\right\}\right]$$

$$M_2 = \frac{1}{15}\left[-\sum_{i=1}^{N_I} P_{Ii}\alpha_{Ii}\left\{1-\left(\frac{\alpha_{Ii}}{l}\right)^2\right\} + \sum_{j=1}^{N_{II}} P_{IIj}\alpha_{IIj}\left(1-\frac{\alpha_{IIj}}{l}\right)\left(2+5\frac{\alpha_{IIj}}{l}\right) + \sum_{k=1}^{N_{III}} 4P_{IIIk}(l-\alpha_{IIIk})\left\{1-\left(\frac{l-\alpha_{IIIk}}{l}\right)^2\right\}\right]$$

$$M_{3j} = \left| R_{II}\alpha_{IIj} - \sum_{r=0}^{j-1} P_{IIr}\left(\alpha_{IIj}-\alpha_{IIr}\right) - \left(\frac{M_2 - M_1}{l}\right)\alpha_{IIj} - M_1 \right|$$

Where:

$P_{II0} = 0$, $\alpha_{II0} = 0$

l: Span (m) of beam between support points

P_{Ii}, P_{IIj} and P_{IIIk}: Maximum design wheel load (kN) between support points

Where the maximum design wheel loads between support points are given in tons, the values of P_{Ii}, P_{IIj} and P_{IIIk} should be multiplied by 9.81 to convert them into kN. Subscript "I_i" means the ith load point from left end of the Ith beam. Subscript "II_j (or II_r)" means the jth (or rth) load point from left end of the IIth beam. Subscript "III_k" means the kth load point from left end of the IIIth beam. (*See* **Fig. CS10.7.1-2**)

α_{Ii}, α_{IIj} and α_{IIIk}: Distance (m) from each support point to the point of action of wheel load (*See* **Fig. CS10.7.1-2**), when wheels are so arranged that M may be at its maximum value

N_I, N_{II} and N_{III} : Number of wheel loads between each span

R_{II}: The value obtained from following the formula

$$R_{II} = \frac{1}{l}\sum_{j=1}^{N_{II}} P_{IIj}(l-\alpha_{IIj})$$

Fig. CS10.7.1-1 Measurement of Wheel Print Length

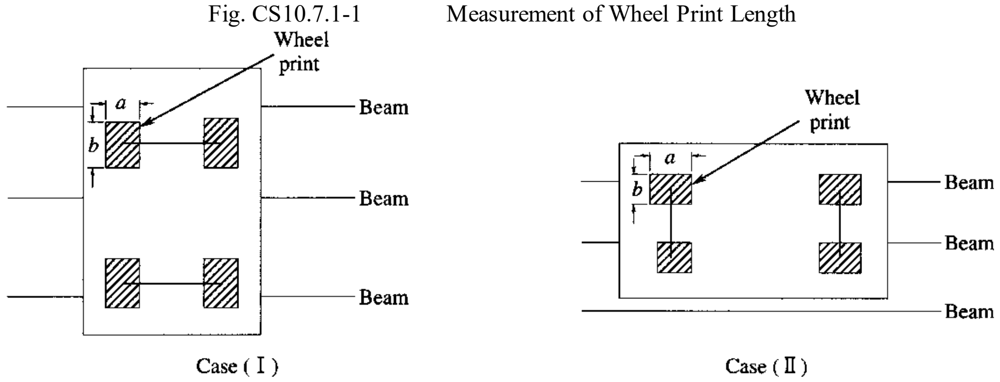


Fig. CS10.7.1-2 Measurement of P_{Ii}, α_{Ii}, l etc.

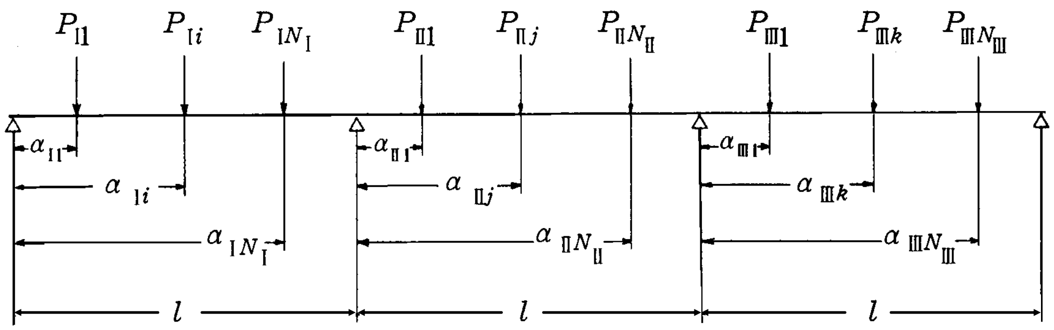


Table CS10.7.1-1 Wheel Print Length (Pneumatic Tires)

	Wheel print length parallel to axle in Fig.CS10.7.1-1, *a* in Case (I), *b* in Case(II)	Wheel print length right angles to axle in Fig.CS10.7.1-1, *b* in Case (I), *a* in Case (II)
Single tire	Tire width	$\sqrt{P}/20$
Double tire	2×Tire width. Gap between tires, if any, may be added	$9\sqrt{P}/250$

Note:

P: Maximum design wheel load (*kN*). Where the maximum design wheel load is given in tons, the value of *P* should be multiplied by 9.81 to convert it into *kN*.

Table CS10.7.1-2. Value of C_2

		Vehicles exclusively used for cargo handing	Other vehicles
Longitudinal beams of strength decks in mid ship region	Decks where vehicles are exclusively loaded (except weather deck)	$\frac{5.6K}{1-0.34f_{DH}K}$	$\frac{7.0K}{1-0.64f_{DH}K}$
	Elsewhere	$\frac{6.1K}{1-0.34f_{DH}K}$	$\frac{7.7K}{1-0.64f_{DH}K}$
Elsewhere	Decks where vehicles are exclusively loaded (except weather deck)	$5.6K$	$7.0K$
	Elsewhere	$6.1K$	$7.7K$

Notes

f_{DH}: Ratio of the section modulus of transverse section of hull at deck according to the requirements in **Chapter 15, Part CS** of the Rules when mild steel is used to the actual section modulus of hull at strength deck. Where the ratio is less than $0.79/K$, f_{DH} is to be assumed as $0.79/K$

K: Coefficient corresponding to the material, as specified in **1.3.1-2, Part CS** of the Rules

2 Scantlings of beams of car decks may be determined by the direct calculation methods shown below.

(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 (fork-lifts or similar vehicles used for handling cargo in ports only)

(3) The allowable stresses for calculation of the section modulus are to be as shown in **Table CS10.7.1-3**.

(4) To take into account the effects of corrosion and similar wear, the section moduli obtained in **(1)**, **(2)** and **(3)** above are to be multiplied by 1.1 for decks exclusively loaded with vehicles (except the weather deck) and 1.2 for other decks.

Table CS10.7.1-3 Permissible Stress (N/mm^2)

Members	Vehicles used for cargo handling only	Other vehicles
Longitudinal beams of strength decks in midship region	$\frac{235}{K}-80f_{DH}$	$\frac{235}{K}-150f_{DH}$
Elsewhere	$\frac{235}{K}$	$\frac{235}{K}$

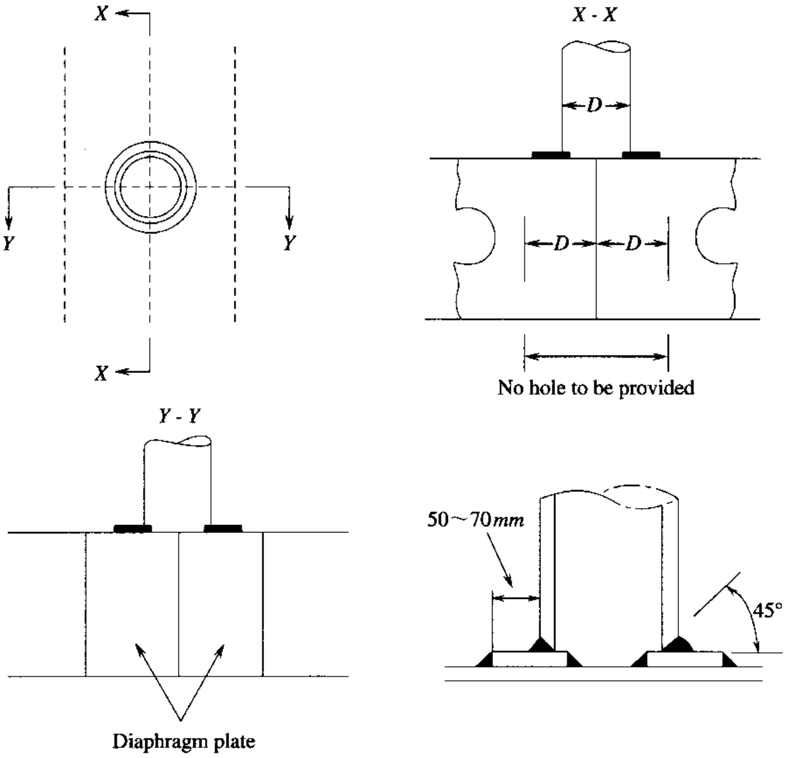
CS11 PILLARS

CS11.1 General

CS11.1.2 Pillars in Holds

The reinforcement under pillars is to be as shown below.

Fig. CS11.1.2-1



CS11.2 Scantlings

CS11.2.1 Sectional Area of Pillars

The sectional area of pillars which can be regarded as fixed at both ends may be obtained from the following formula:

$$\frac{0.223w}{2.72-\frac{0.5l}{k_0}} \quad (cm^2)$$

CS12 DECK GIRDERS

CS12.1 General

CS12.1.3 Construction

1 At the upper and lower ends of pillars and other places where concentrated loads are expected, girders are to be fitted with tripping brackets and slots in the girders are to be fitted with collars. Under the end bulkheads of superstructures, only collars are required. Collars are also to be fitted at the slots near the toes of end brackets.

2 Butt joints of girder webs are to be away from slots. Butt joints of face plates are to be away from knuckled parts. The depth of slots is not to exceed $0.4d_G$. If this limit is exceeded, collars are to be fitted. This depth is not to exceed $0.5d_G$. These requirements may be suitably modified for superstructures.

3 Sizes of lightening holes are to be as follows:

Girder with slot: $d \leq \frac{d_G}{4}$

Girder without slot: $d \leq \frac{d_G}{3}$

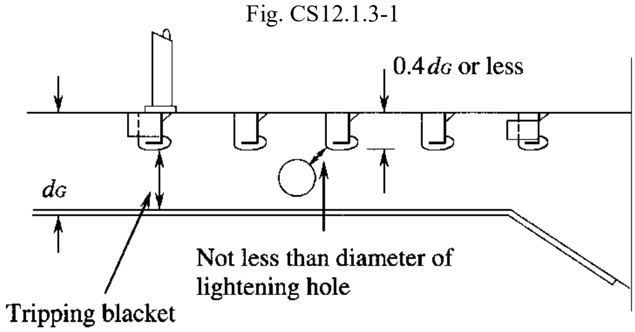
Where:

d_G: Depth of girder

d : Diameter of lightening hole

No lightening hole is to be provided near the toes of brackets or under pillars where shearing force is augmented. The distance between the lightening hole and slot is not to be less than the diameter of the lightening hole. (*See* **Fig. CS12.1.3-1**)

Fig. CS12.1.3-1



4 In ships such as RO-RO ships, the scantlings of girders may be determined by direct calculation of strength.

5 Where the value obtained from the following formula is not less than 1.6, special consideration is to be given to the beams on the shell side or bulkhead side around the mid-span of girders because of added stress due to forced deflection.

$$\frac{I_b l^4}{I_g S b^3}$$

Where:

I_b and I_g : Actual moment of inertia (cm^4) of beam and girder, respectively

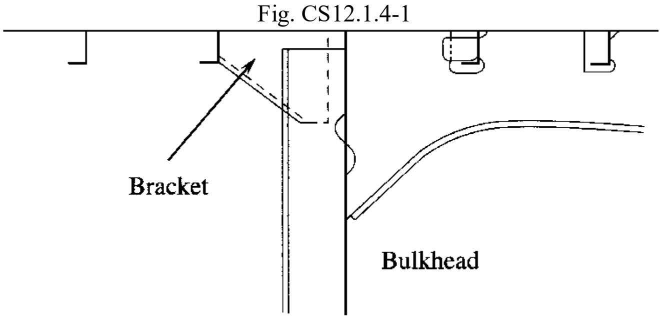
b and l : Span (m) of beam and girder, respectively

S : Beam spacing (m).

CS12.1.4 End Connection

1 Where a girder stops at a bulkhead, a bracket is to be fitted on the reverse side. (*See* **Fig. CS12.1.4-1**)

Fig. CS12.1.4-1



2 Continuity of Deck Girders

(1) The standard depth of a bracket is twice the depth of a web. If the depth of the bracket is smaller than this standard, suitable equivalent means, such as attaching a gusset plate, is to be provided. (*See* **Fig. CS12.1.4-2**)

(2) The girder included in the calculation of the section modulus is to completely penetrate the bulkhead (including the web and face plate) or is to be connected in a way that ensures an equivalently secure bond. (*See* **Fig. CS12.1.4-3**)

(3) Where deck girders are discontinuous, they are to be sufficiently overlapped. (*See* **Fig. CS12.1.4-4**)

Fig. CS12.1.4-2

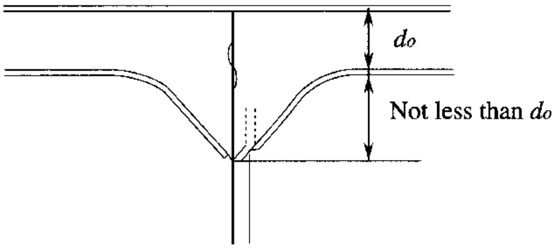


Fig. CS12.1.4-3

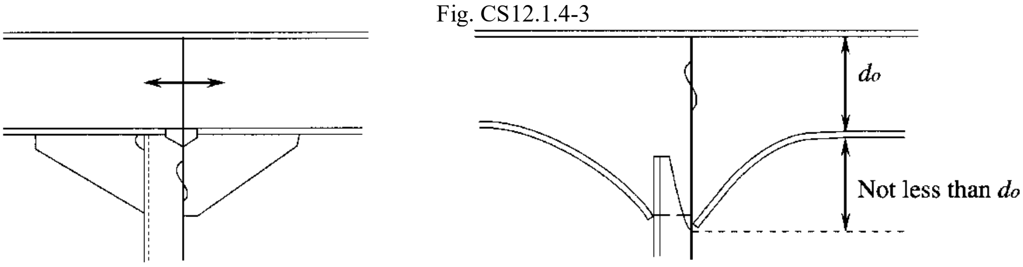
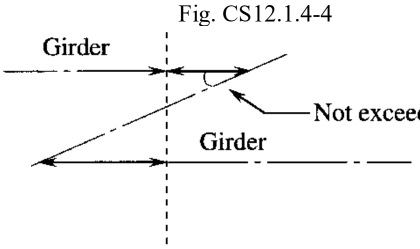


Fig. CS12.1.4-4



CS12.2 Longitudinal Deck Girders

CS12.2.1 Section Modulus of Girders

The section modulus of longitudinal deck girders outside the line of hatchway openings of the strength deck fore and aft of the midship part is generally determined by interpolation as stipulated in **12.2.1-1** and **12.2.1-2, Part CS** of the Rules. Interpolation is to be performed at the centre of the girder's span. However, this may be modified when taking into consideration factors such as the length of building blocks.

CS13 WATERTIGHT BULKHEADS

CS13.1 Arrangement of Watertight Bulkheads

CS13.1.1 Collision Bulkheads

1 The position of the collision bulkhead is to be determined as shown below.

(1) In case of a Bulbous Bow (*See* **Fig. CS13.1.1-1**)

(When the stem has a hollowed part over the waterline at 85% of the least moulded depth measured from the top of the keel)

(2) In case of a Collision Bulkhead with a Step or Recess (*See* **Fig. CS13.1.1-2**)

Fig. CS13.1.1-1

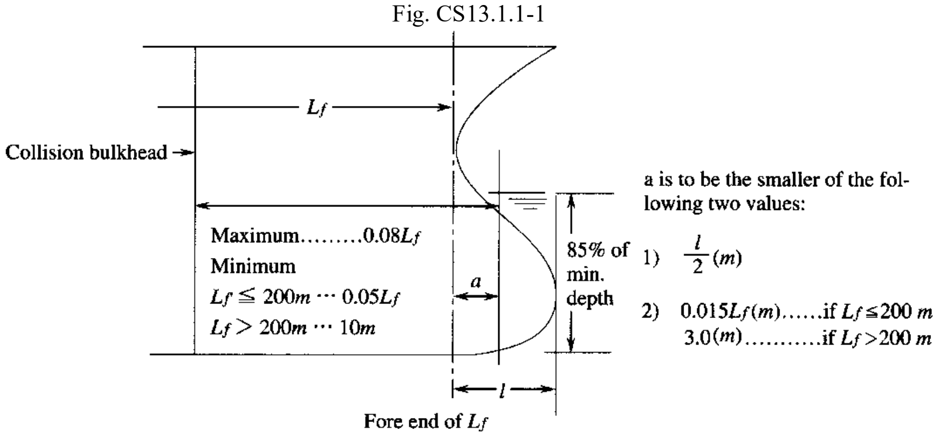
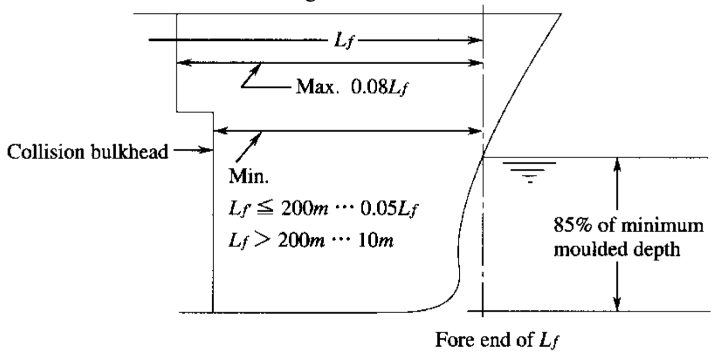


Fig. CS13.1.1-2



2 In ships with bow doors, the collision bulkhead under the deck just above the freeboard deck is to comply with the requirements mentioned in **13.1.1-1** and **-2** and **13.1.5(2), Part CS** of the Rules.

3 "Special structural reasons which are approved by the Society" in **13.1.1-1, Part CS** of the Rules are reasons approved on the basis that an application is submitted together with calculations verifying that no part of the bulkhead deck will be immersed even when the compartment forward of the collision bulkhead is flooded under loaded conditions (without trim) corresponding to the load line.

CS13.1.2 After Peak Bulkheads

Measures to minimize the danger of water penetrating into the ship in case of damage to stern tube arrangements are to be taken.

CS13.1.4 Hold Bulkheads

1 Where the distance between two neighbouring bulkheads is less than $0.7\sqrt{L}\ m$, these two bulkheads are not counted as two bulkheads.

2 Where the number of watertight bulkheads is smaller than that specified in **13.1.4-1, Part CS** of the Rules, due attention is to be paid to the transverse strength of the hull in accordance with the requirements of **13.1.4-2, Part CS** of the Rules, and the number of watertight bulkheads may be in accordance to one of the following **(1)** to **(3).** Where the number of watertight bulkheads is decreased from that required according to the following **(2)**, an application for the omission of bulkheads stating the reasons for such omission is to be submitted by the shipowner to the Society.

(1) The number of bulkheads arranged in accordance with the following **(a)** and **(b)**.

(a) The ships has sufficient transverse strength of hull

(b) The final waterline does not exceed the upper surface of the bulkhead deck at the side of the ship even after any compartment, except the machinery space, has been flooded under the loading condition corresponding to the summer load water line. The permeability used in flooding calculations is to be in accordance with **Table CS13.1.4-1** and **Table CS13.1.4-2**. However, the following ships are exempted from this calculation.

(i) Tankers in compliance with the requirements of **3.2.2, Part 3 of the Rules for Marine Pollution Prevention Systems**

(ii) Ships carrying liquefied gases in bulk or ships carrying dangerous chemicals in bulk

(iii) Ships in compliance with the requirements of **Chapter 4, Part CS** of the Rules (including ships specified in **CS4.1.1**)

(2) For ships of special types, the number is in accordance with **(a)**, **(b)** or **(c)**

(a) Ships carrying long cargoes (rails, sheet piles or similar long cargoes), train ferries, and car carriers, may omit one bulkhead where the required number is 5 or less, and 2 bulkheads where the required number is 6 or more

(b) Ships having conveyor systems for handling cargoes may omit all the hold bulkheads, if necessary

(c) Ships other than those specified above are, as a rule, not regarded as special type ships

(3) Where special consideration is given for improving safety of ships by means such as that of a double hull, the arrangement of watertight bulkheads may be different from that required in the Rules.

Table CS13.1.4-1 Permeability of Cargo Spaces

Cargo spaces	Permeability
empty	0.95
loaded with general cargo	0.60
loaded with timber	0.55
loaded with ore	0.50
loaded with cars or containers	$0.95 - 0.35 \times \frac{V_C}{V_0}$

Notes:

V_C: Volume (m^3) occupied by cars and/or containers

V_0: Moulded volume (m^3) of the compartment

Table CS13.1.4.-2 Permeability of Deep Tanks

Cargo condition	Permeability
empty	0.95
filled	0

Note:

For spaces loaded with special kinds of cargo, a suitable permeability is used depending on the kind of cargo.

CS13.1.5 Height of Watertight Bulkheads

A "long forward superstructure" means a forward superstructure having a length not less than $0.25L_f$.

CS13.2 Construction of Watertight Bulkheads

CS13.2.3 Stiffeners

1 Scantlings of bulkhead stiffeners just under deck girders

The scantlings of bulkhead stiffeners supporting under-deck girders are to comply with the following formula:

$$C\frac{Z_0}{Z}+\frac{W}{A}\leq C$$

Z_0: Required section modulus (cm^3) of stiffener

Z : Actual section modulus (cm^3)

C : 17.7

A : Sectional area (cm^2) of stiffener (may include attached plate)

W: Axial load (kN) of stiffener obtained from the following formula:

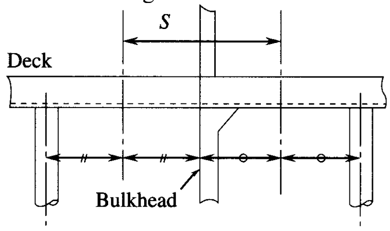
Sbh

S : Distance (m) between mid-spaces of adjacent girders supported by stiffeners (*See* **Fig. CS13.2.3-1**)

b and h : As specified in **12.2.1, Part CS** of the Rules.

In ships having two or more decks, W for the upper tier deck need not be taken into consideration.

Fig. CS13.2.3-1



2 Scantlings of bulkhead stiffeners just under cargo gears and deck girders

The scantlings of bulkhead stiffeners just under cargo gears and deck girders are to comply with **-1** above using the value obtained from following formula as the axial load on the stiffener. Where the stiffeners support only tare weight of cargo gears, the first term in the formula may be zero.

$Sbh+P$ (kN)

S, b and h : As specified in above **-1**

P : Tare weight of cargo gears (kN)

For derrick systems, it may be acceptable to use the value shown in **Table CS13.2.3-1** according to the type of derrick system and the arrangement of derrick booms.

Table CS13.2.3-1 Tare Weight of Derrick Systems (kN)

Arrangement of Derrick Booms	Type of Derrick Post	
	Independent type	Gate type
Booms arranged only on fore or aft side	2.0w	2.3w
Booms arranged on both sides	2.7w	3.0w

Note:

Where, w : Safe working load (kN) of each boom

For booms arranged on both sides, the average value is to be taken.

3 Dimensions of brackets of bulkhead stiffeners

The dimensions of brackets of bulkhead stiffeners are to be as indicated in **Fig. CS13.2.3-2**.

4 Support of stiffeners at decks

Where a deck terminates at the bulkhead, the stiffeners are to have ribs at the level of the deck. (*See* **Fig.CS13.2.3-3**)

Fig. CS13.2.3-2

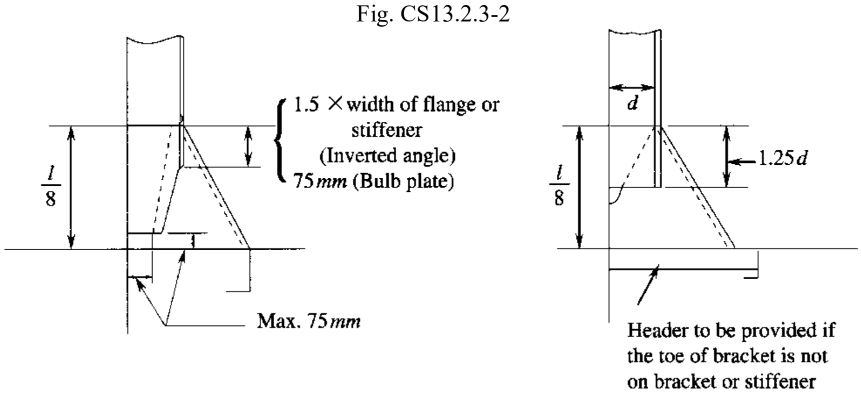
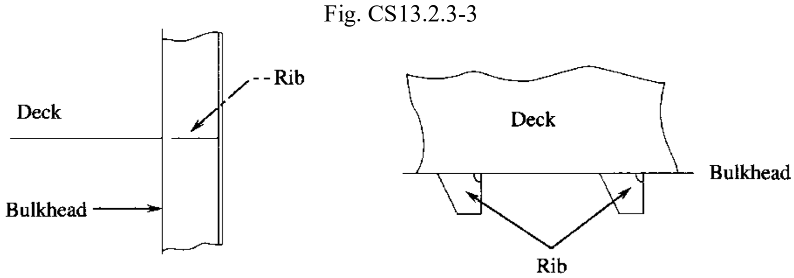


Fig. CS13.2.3-3



CS13.2.9 Corrugated Bulkheads

1 Section modulus of corrugated bulkheads

Where the end connection of corrugated bulkheads is remarkably effective, the coefficient C in **13.2.9-2, Part CS** of the Rules may be the value taken from **Table CS13.2.9-1** in calculating the section modulus per half pitch. “Remarkably effective” means the following:

(1) The value of m_1 specified in **Table CS13.2.9-1.** is greater than 0.2 for the connection of the upper end of the corrugated bulkhead to the deck

(2) The value of m_2 specified in **Table CS13.2.9-1.** is greater than 0.6 for the connection of the upper end of the corrugated bulkhead to the stools

(3) The plate thickness of lower stools is not less than half the thickness of the face plates of the corrugated bulkhead for the connection of the lower end of the corrugated bulkhead to the stools

2 Construction of corrugated bulkheads

(1) Stiffeners are to be provided at the ends of under-deck girders.

(2) Where brackets are fixed to bulkhead plates, pads or headers are to be fitted at the bracket toe.

(3) The angle of corrugation is to be not less than 45°.

(4) Girders fitted to corrugated bulkheads are to be balanced girders, except where the strength of such girders is at least equivalent to that of girders fitted to flat bulkheads. In calculating the actual section modulus of the girder, the depth of the girder is to be taken as shown in **Fig. CS13.2.9-3**. The bulkhead plate of corrugated bulkheads is not to be included into the section modulus of the girder as an effective attached plate.

(5) The lower end of the corrugated bulkhead is to be constructed as shown in **Fig. CS13.2.9-4** (A) or (B). The construction of the upper end is recommended to follow the construction of the lower end.

Table CS13.2.9-1 Coefficient C

Col.	Other ends	C		
		One end of bulkhead		
		Supported by horizontal or vertical girders	Upper end welded directly to deck	Upper end welded to stool efficiently supported by ship structure
1	Supported by horizontal or vertical girders or lower end of bulkhead welded directly to decks or inner bottoms	As per the Rules	$\dfrac{4}{2+m_1+\frac{Z_2}{Z_0}}$	$\dfrac{4}{2+m_2+\frac{Z_2}{Z_0}}$
2	Lower end of bulkhead welded to stool efficiently supported by ship structure	$\dfrac{4.8\left(1+\frac{l_H}{l}\right)^2}{2+\frac{Z_1}{Z_0}+\frac{Z_H}{Z_0}}$	$\dfrac{4.8\left(1+\frac{l_H}{l}\right)^2}{2+m_1+\frac{Z_H}{Z_0}}$	$\dfrac{4.8\left(1+\frac{l_H}{l}\right)^2}{2+m_2+\frac{Z_H}{Z_0}}$
		Not to be less than value of Column 1		

Notes:

In the above table, Z_0, Z_1, Z_2, l_H and l are to be as per the Rules.

m_1 is to be obtained from the following formula for the upper end but it need not exceed Z_1/Z_0.

$$\frac{1}{Z_0}\left[Z_S+\left(\frac{l_L+d_0}{l_L-d_0}+1.0\right)Z_L\right]$$

Z_S is the section modulus (cm^3) of the continuous stiffener at the upper end (*See* **Fig. CS13.2.9-1**).

l_L and Z_L are the span (m) and section modulus (cm^3) of the longitudinal member connected to the upper end. (*See* **Fig. CS13.2.9-1**)

d_0 is as per the Rules.

m_2 is to be obtained from the following formulae, whichever is smaller.

$$\frac{1}{Z_0}\times\frac{1050At}{n}$$

$$3.6\left(\frac{l}{l_0}\right)^2-3$$

A : Area (m^2) enclosed by periphery upper stool (*See* **Fig. CS13.2.9-2**)

t : Average plate thickness (mm) of upper stool (*See* **Fig. CS13.2.9-2**)

n : Number of pitches of corrugation supported by upper stool (*See* **Fig. CS13.2.9-2**)

l_0 : Distance (m) between insides of upper and lower stools (*See* **Fig. CS13.2.9-2**)

Z_H: Section modulus (cm^3) per half pitch of lower end of lower stool (*See* **Fig. CS13.2.9-2**)

Fig. CS13.2.9-1

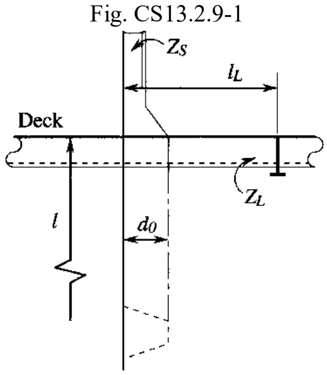


Fig. CS13.2.9-2

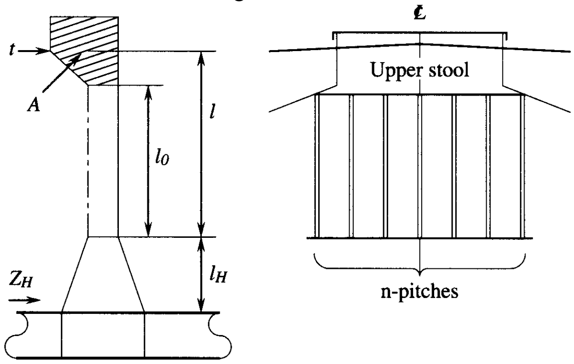


Fig. CS13.2.9-3. Depth of Girder

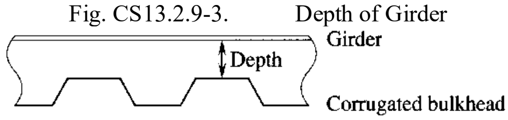
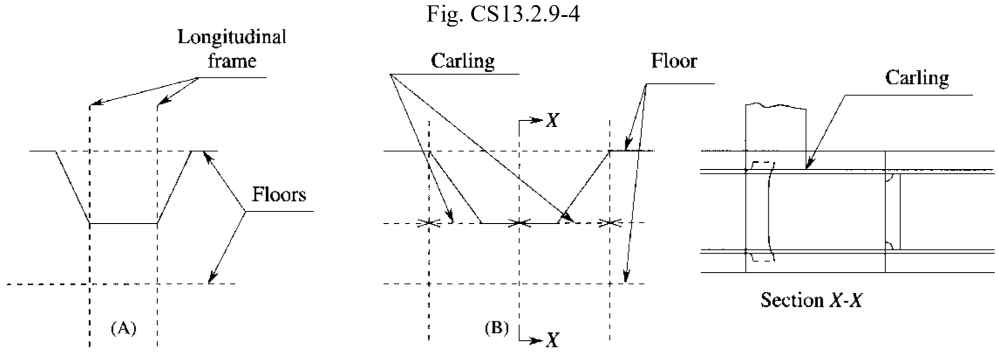


Fig. CS13.2.9-4



CS13.3 Watertight Doors

CS13.3.1 General

1 With respect to the provisions of **13.3, Part CS** of the Rules, watertight doors are categorized as the following **(1)** to **(3)** corresponding to their purpose and frequency of use.

(1) Watertight doors which are to be permanently closed at sea

Such doors are open in port and closed before the ship leaves port (*e.g.* bulkhead doors for loading/unloading). The time of opening/closing such doors is to be entered in the log-book.

(2) Watertight doors which are to be normally closed at sea

Such doors are kept closed at sea but may be used if authorized by the officer of the watch and to be closed again after use.

(3) Watertight doors which are used at sea

Kept closed, but may be opened during navigation when authorized by the Administration to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates it being opened. The door, however, is to be immediately closed after use.

2 The requirements of **13.3, Part CS** of the Rules apply to watertight doors required by other regulations regarding damage stability requirements. Watertight doors located above the bulkhead deck are to also comply with the requirements for doors provided for means of escape specified in **Chapter 13, Part R** of the Rules.

3 With respect to the provisions of **13.3**, **Part CS** of the Rules, **Table CS4.3.1-1** and **Table CS4.3.1-2** are also referenced as general requirements for watertight doors.

CS13.3.2 Types of Watertight Doors

Watertight doors provided in watertight bulkheads are to be of a sliding type as far as is practicable. If hinged doors are used, they are to be accessible at any time.

CS13.3.3 Strength and Watertightness

1 "Where deemed necessary by the Society" in **13.3.3-1, Part CS** of the Rules refer to cases other than those specified in the following **(1)** to **(3)**.

(1) The prototype of such doors has been tested by design water pressure

(2) The design of such doors has been verified to have enough strength and watertightness by direct structural analysis

Where watertight doors utilize gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection is to be carried out.

(3) Such doors are complying with a standard deemed appropriate by the Society

2 Hydrostatic tests specified in **13.3.3-1, Part CS** of the Rules are to be carried out as follows:

(1) The head of water used for the hydrostatic test is to correspond at least to the head measured from the lower edge of the door opening (at the location in which the door is to be fitted in the ship) to 1 *m* above the freeboard deck. However, for watertight doors subject to **4.3.1, Part CS** of the Rules, the head is not to be less than the height of the final damage waterline or the intermediate waterline, whichever is greater.

(2) The acceptable leakage rate at the test is not to be greater than the following values.

(a) Doors with gaskets: No leakage

(b) Doors with metallic sealing: 1 *l/min*

(3) Notwithstanding **(2)** above, the following leakage rate may be accepted for hydrostatic tests on large doors located in cargo spaces employing gasket seals or guillotine doors located in conveyor tunnels.

(a) For doors of design head exceeding 6.10 *m*:

$$\frac{(P+4.572)\cdot h^3}{6568} \quad (l/min)$$

P: Perimeter of door opening (m)

h: Test head of water (m)

(b) For doors with a design head not exceeding 6.10 *m*, the acceptable leakage rate is the value calculated by the formula specified in **(a)** above or 0.375 *l/min*, whichever is greater.

CS13.3.4 Control

1 Where it is necessary to start the power unit for remote operation of the watertight door required by **13.3.4, Part CS** of the Rules, means to start the power unit is also to be provided at remote control stations.

2 Remote controls required by **13.3.4, Part CS** of the Rules, are to be in accordance with the following.

(1) The operating console at the navigation bridge is to have a "master mode" switch with the following two modes of control. This switch is normally to be in the "local control" mode. The "doors closed" mode is only used in an emergency or for testing purposes. Special consideration is to be given to the reliability of the "master mode" switch.

(a) "Local control" mode

This mode is to allow any door to be locally opened and locally closed after use without automatic closure.

(b) "Doors closed" mode

This mode is to permit doors to be opened locally and automatically reclose the doors upon release of the local control mechanism.

(2) The operating console at the navigation bridge is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate that a door is fully open and a green light is to indicate that a door is fully closed. When the door is closed remotely, the red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

3 Where remote control is required by **13.3.4, Part CS** of the Rules, signboard/instructions are to be placed in way of the door advising how to act when the door is in the "doors closed" mode.

4 With respect to the provisions of **13.3.4, Part CS** of the Rules, where a watertight door is located adjacent to a fire door, both doors are to be capable of independent operation, remotely if required and from both sides of each door.

5 "Navigation bridge" stated in **13.3.4, Part CS** of the Rules means the place where the watch officer is always present and normally implies the navigation bridge deckhouse.

6 With respect to the provisions of **13.3.4-1, Part CS** of the Rules, operation capability with the ship listed at 30 *degrees* to either side is to be verified by tests such as the prototype test.

7 With respect to the provisions of **13.3.4-1, Part CS** of the Rules, power operated doors are also to be capable of being opened and closed by power, in addition to by hand.

CS13.3.5 Indication

1 For watertight doors with dogs/cleats for securing watertightness, position indicators required by **13.3.5, Part CS** of the Rules are to be provided to show whether all dogs/cleats are fully and properly engaged or not.

2 With respect to the provisions of **13.3.5, Part CS** of the Rules, a position indicator may not be required for doors which are designed to confirm easily whether the doors are open or closed from either side and, if applicable, all dogs/cleats are fully and properly engaged or not.

3 The door position indicating system required by **13.3.5, Part CS** of the Rules is to be of a self-monitoring type and the means for testing it are to be provided at the position where the indicators are fitted.

4 "Position indicators on the bridge showing whether the doors are open or closed" required by **13.3.5, Part CS** of the Rules is to be in accordance with **CS13.3.4-2(2)**.

5 "Those permanently closed at sea" stated in **13.3.5, Part CS** of the Rules means "other closing appliances which are kept permanently closed at sea" stated in **4.3.1-2(4), Part CS** of the Rules.

CS13.3.6 Alarms

An audible alarm required by **13.3.6-2, Part CS** of the Rules is to have a sound distinctive from any other alarms in the area, which will sound whenever the door is remotely closed.

CS13.3.7 Power Sources

"Electrical installations for devices specifies in **-1**" stated in **13.3.7-2, Part CS** of the Rules refers to electrical motors for opening and closing the doors and their control components; indicators that show whether the doors are opened or closed; audible alarms; and limit switches for ensuring the door position and their associated cables.

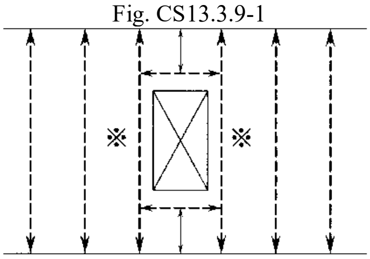
CS13.3.8 Notices

"A device which prevents unauthorized opening" stipulated in **13.3.8-2, Part CS** of the Rules can be a lock that prevents access to closing and/or operating apparatus.

CS13.3.9 Sliding Doors

The section moduli of stiffeners adjacent to both sides of sliding doors (indicated with an asterisk in **Fig. CS13.3.9-1**) are to be determined by the formula for stiffeners of deep tank bulkheads. The upper end of *h* in the formula is to be the bulkhead deck at the centreline of hull.

Fig. CS13.3.9-1



CS14 DEEP TANKS

CS14.1 General

CS14.1.3 Divisions in Tanks

1 Length of deep tanks

The length of deep tanks is not to exceed the following limits.

(1) Where no longitudinal bulkhead is provided or a longitudinal bulkhead is provided on the centreline only:

$0.15L_f$ (m) or 10 m, whichever is greater

(2) Where two or more longitudinal bulkheads are provided:

$0.2L_f$ (m) except that the limit is to be $0.15L_f$ (m) in the bow and stern parts of bulk carrier type ships

Further, where the breadth of the wing tank is less than $4L + 500$ (mm), the inner wall cannot be regarded as a longitudinal bulkhead.

2 Divisions

(1) Except in the bow and stern parts, deep tanks extending from side to side of the ship are to have longitudinal divisions in the ship's centreline. However, when it can be confirmed by the stability data that such bulkheads will be unnecessary, they might be omitted.

(2) In fresh water tanks extending from side to side of the ship, fuel oil tanks or other tanks which may not be kept completely full during navigation, wash plates or deep girders are to be provided on the centreline as well as in positions approximately $B/4$ distant from the ship's sides, except when it can be confirmed by the data on the rolling period of the ship and the inherent period of oscillation of water or oil in the tanks, that they will be unnecessary.

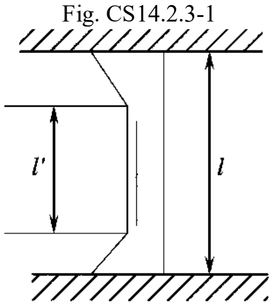
CS14.2 Deep Tank Bulkheads

CS14.2.3 Bulkhead Stiffeners

1 Span of stiffeners

For stiffeners having "Connection Type A," the span may be taken as $4l'/3$ if the arm length of brackets exceed $l/8$. For "Connection Type A," *see* **Fig. CS14.2.3-1**.

Fig. CS14.2.3-1



2 End connection of stiffeners at the top of deep tanks

Stiffeners of deep tank bulkheads, which are not in line with stiffeners of tween deck bulkheads at the top of the tank, are to have bracket ends.

3 Scantlings of bulkhead stiffeners supporting under-deck girders

The scantlings are to be calculated according to **CS13.2.3-1**, taking C as 9.81.

CS14.2.8 Corrugated Bulkheads

1 Upper and lower structures supporting corrugated bulkheads

(1) In cases where stools are not fitted with corrugated bulkheads, the standard upper and lower structures supporting the corrugated

bulkheads are to be in accordance with **Table CS14.2.8-1**.

(2) In cases where a stool is fitted with a corrugated bulkhead, the standard lower stool and structures supporting such a lower stool are to be in accordance with the following **(a)** and **(b)**:

(a) The thickness of the top plate and the uppermost part of the side plating of the lower stool is to be the same as that of the lower part of the corrugated bulkhead.

(b) At the bottom of a lower stool, floors in a double bottom are to be arranged beneath the side plating of the lower stools for transverse corrugated bulkheads and girders (center girders or side girders) are to be arranged beneath the side plating of the lower stools for longitudinal corrugated bulkheads. In addition, the thickness of the upper part of floors and girders are to be the same as that of the side plating of the lower stool.

(3) In cases **(1)** and **(2)** above, any openings such as slots or scallops providing penetration for stiffeners to a floor, web of transverses or girders are to be eliminated or covered by collar plates.

Table CS14.2.8-1 Upper and Lower Structures Supporting Corrugated Bulkheads

Type of corrugated bulkhead		Location	Supporting structure
Vertically corrugated bulkhead	Transverse	Lower	Floors with a thickness that is the same as that of the lower part of a corrugated bulkhead are to be arranged beneath both flanges of the corrugated bulkhead or a floor with a thickness that is the same as that of the lower part of a corrugated bulkhead is to be arranged beneath one flange of the corrugated bulkhead and a bracket with a web depth that is not less than 0.5 times the depth of the corrugation is to be arranged beneath the other side flange of the corrugated bulkhead. (See **Fig.CS14.2.8-1.**)
	Longitudinal	Upper	An on-deck longitudinal girder or an on-deck longitudinal with a web thickness of not less than 80% of the thickness of the upper part of a corrugated bulkhead is to be arranged above both flanges of the corrugated bulkhead.
		Lower	Girders (center girders or side girders) with a thickness that is the same as that of the lower part of a corrugated bulkhead are to be arranged beneath both flanges of the corrugated bulkhead or a girder with a thickness that is the same as that of the lower part of a corrugated bulkhead is to be arranged beneath one flange of the corrugated bulkhead and an inner bottom longitudinal with a web depth that is not less than 0.5 times the depth of the corrugation or an equivalent stiffener is to be arranged beneath the other side flange of the corrugated bulkhead.
Horizontally corrugated bulkhead	Transverse	Lower	A floor with a thickness that is the same as that of the lower part of a corrugated bulkhead is to be arranged beneath the web of the corrugated bulkhead.
	Longitudinal	Upper	An on-deck longitudinal girder with a web thickness that is not less than 80% of the thickness of the upper part of a corrugated bulkhead is to be arranged above the web of the corrugated bulkhead.
		Lower	A girder (center girder or side girder) with a thickness that is the same as that of the lower part of a corrugated bulkhead is to be arranged beneath the web of the corrugated bulkhead.

2 Section modulus of corrugated bulkheads

Where the width d_H in the direction of the ship's length of the lower stool of the corrugated bulkhead at the inner bottom is less than 2.5 *times* the web depth d_0 of the corrugated bulkhead, the span l between supports is to be measured as shown in **Fig. CS14.2.8-2**. Further, the section modulus per half pitch of the corrugated bulkhead and the section modulus of the lower stool at the inner bottom are to be obtained from the formulae in **14.2.8-2, Part CS of the Rules**, using the value of C in **Table CS14.2.8-2**.

3 Construction of corrugated bulkheads

The corrugation angle, ϕ, of a corrugated bulkhead is not to be less than 55 degrees. (See **Fig. CS14.2.8-3.**)

4 In evaluating the corrugated bulkheads of compartments intended to carry liquid cargoes with specific gravity, ρ, more than

1.0, the scantlings of the corrugated bulkheads are to be calculated by multiplying h by ρ before using the formulae specified in **14.2.8-1** to **-3, Part CS of the Rules**.

Fig. CS14.2.8-1 Example of Structures Supporting Vertically Corrugated Bulkheads (Transverse Bulkheads)

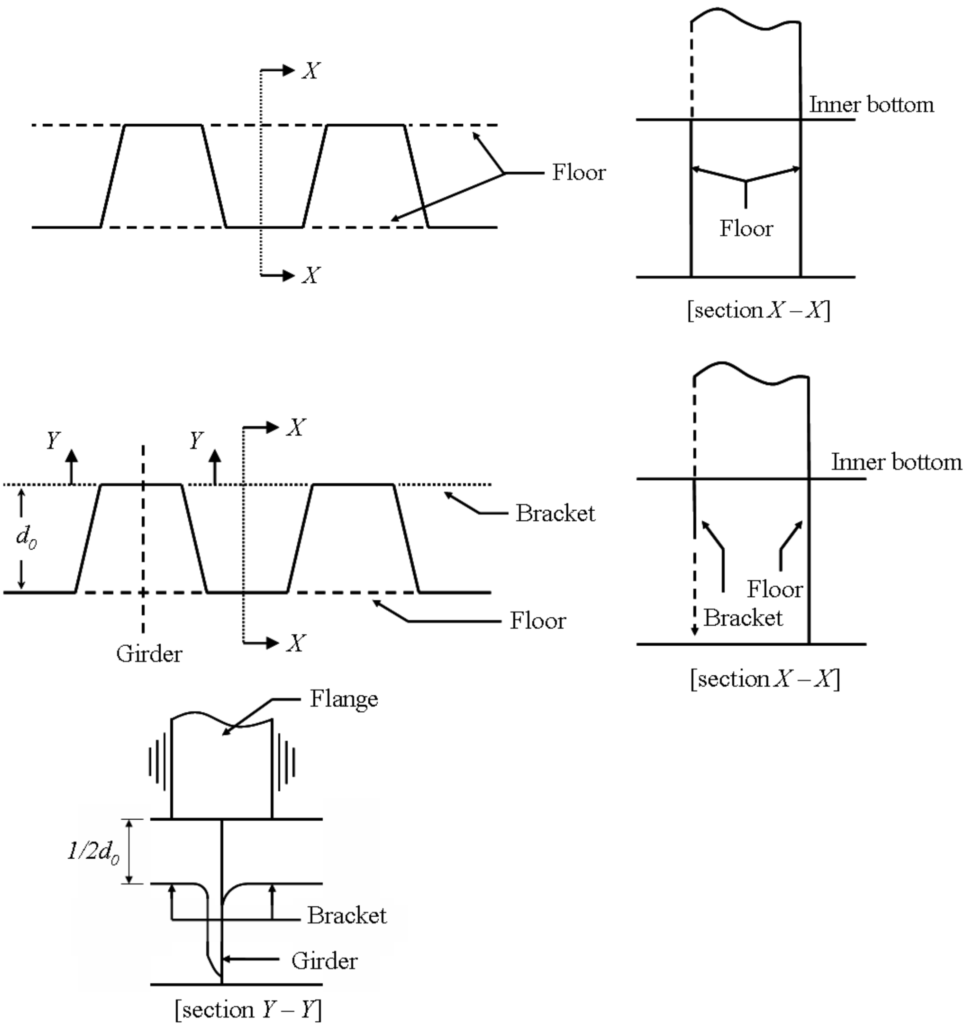
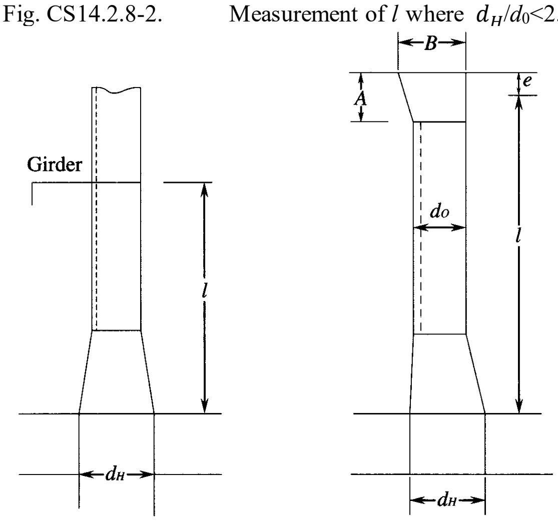


Fig. CS14.2.8-2. Measurement of l where $d_H/d_0<2.5$



$$e = A - \frac{d_0}{2B}A$$

Fig. CS14.2.8-3. Definition of the Corrugation Angle of a Corrugated Bulkhead

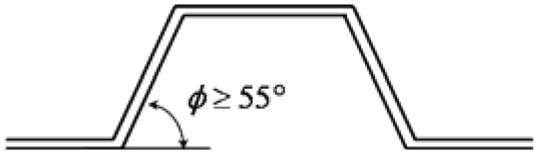


Table CS14.2.8-2 Coefficient C

Upper end support	Supported by girder	Connected to deck	Connected to stool
Section modulus of corrugated bulkhead	1.00	0.85	0.78
Section modulus of stool at bottom	1.00	1.50	1.35

CS15 LONGITUDINAL STRENGTH

C15.1 General

C15.1.1 Special Cases in Application

The ships stated in **15.1.1, Part CS** of the Rules are to be treated as follows.

(1) Ships of unusual proportion

For ships that have L/B<5 or B/D_S>2.5, adequate consideration is to be given regarding overall strength of the ships in addition to the requirements in **Chapter 15, Part CS** of the Rules.

(2) Ships with especially large hatches

Ships that have hatches with a breadth exceeding $0.7B$ in the midship part are to have their torsional strength examined.

(3) Ships with especially small C_b

Where C_b' specified in **15.2.1-1, Part CS** of the Rules is less than 0.65, Z_σ specified in **15.2.1-1, Part CS** of the Rules is to be obtained by multiplying by the following coefficient according to the value of C_b'.

$C_b' \leq 0.60$: 1.05

$0.60 < C_b' < 0.65$: 1.65-C_b'

(4) Ships with large flares and high ship speed

According to the values of K_v and K_f obtained from the following formulae, M_w specified in **15.2.1-1, Part CS** of the Rules is to be increased in accordance with the requirements in **(a)** and **(b)**.

$$K_v = 0.2V/\sqrt{L_1}$$

$$K_f = (A_d - A_W)/L_1 h_B$$

Where:

A_d: Area (m^2) projected onto a horizontal plane of exposed deck forward of $0.2L_1$ aft of the fore end (including the part forward of the fore end)

Where a forecastle is provided, the horizontal project area of the forecastle overlaps the aforementioned area.

A_W: Water plane area (m^2) corresponding to the designed maximum load line within the forward $0.2L_1$

h_B: Vertical distance (m) from designed maximum load line to exposed deck at the side of fore end

(a) Where K_v exceeds 0.28

C_2 specified in **15.2.1-1, Part CS** of the Rules is to be replaced with the value given in **Table CS15.1.1-1** according to the values of K_v and x which is the distance (m) from aft end of L to the position of the considered hull transverse section. For intermediate values of K_v and/or x, the value is to be determined by interpolation.

(b) Where $(K_v + K_f)$ exceeds 0.40

C_2 specified in **15.2.1-1, Part CS** of the Rules is to be replaced with the value given in **Table CS15.1.1-2** according to the values of (K_v+K_f) and x only under sagging conditions. For intermediate values of (K_v+K_f) and/or x, the value is to be determined by interpolation.

(5) Other ships

Where the requirements in **15.2.1, Part CS** of the Rules apply, B may be replaced with B_{WL} which is the moulded breadth corresponding to the designed maximum load line at the widest section of the ship. (*See* **Fig. CS15.1.1**)

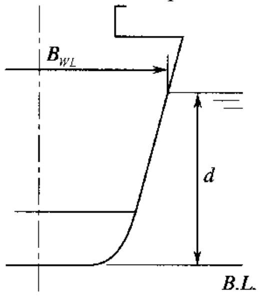
Table CS15.1.1-1 Modified Value of C_2

K_v	X		
	$0.65L_1$	$0.75L_1$	$1.0L_1$
0.28	1.0	5/7	0
0.32 and over	1.0	0.8	0

Table CS15.1.1-2 Modified Value of C_2

$K_v + K_f$	X		
	$0.65L_1$	$0.75L_1$	$1.0L_1$
0.40	1.0	5/7	0
0.50 and over	1.0	0.8	0

Fig. CS15.1.1 Breadth of Ships with Inclined Sides



CS15.2 Bending Strength

CS15.2.1 Bending Strength at the Midship Part

1 With respect to the provisions of **15.2.1, Part CS of the Rules**, calculation of the longitudinal bending moment in still water is to be as follows.

(1) To perform the calculation of longitudinal bending moment in still water, the method of calculation used is to be submitted for prior approval by the Society.

(2) For ships intended to be built under Classification survey, calculation sheets for longitudinal strength in still water corresponding to the actual loading plans and the data necessary for the calculations are to be submitted to the Society.

(3) In the Classification Survey, longitudinal strength calculations in still water are to be performed at the time of completion of the ship on each type of operating condition, and the necessary data and results of these calculations are to be included in the loading manual specified in **25.1.1, Part CS of the Rules**.

(4) Where ballast conditions in the actual loading plans (including intermediate conditions specified in **An1.3.1-2. in Annex 3.8, Part 1, Part C of the Rules**) involve partially filled ballast tanks, such conditions where such ballast tanks are assumed to be empty or full are to be included with the calculation sheets for longitudinal strength specified in **(2)** above. Where two or more ballast tanks are partially filled simultaneously at departure, arrival or during the intermediate conditions specified in **An1.3.1-2. in Annex 3.8, Part 1, Part C of the Rules**, all possible combinations with these ballast tanks empty or full are to be considered.

(5) In cargo loaded conditions, the requirements of **(4)** above are to apply to the peak tanks only.

(6) For large wing ballast tanks of ore carriers as defined in **1.3.1(13)(b), Part B of the Rules**, an examination for partially filled ballast tanks specified in **(4)** above, may be according to the following.

(a) Where the ship's trim exceeds one of the following conditions when one or two pairs of these tanks are empty or have full ballast water filling levels, it is sufficient to demonstrate compliance with maximum, minimum, and intended partial filling levels of these tanks such that the ship's condition does not exceed any of these trim limits.

i) Trim by stern of 3% of the ship's length (L_1)

ii) Trim by bow of 1.5% of ship's length (L_1)

iii) Any trim that cannot maintain propeller immersion (I/D) of not less than 25%, where:

I = the distance from propeller centreline to the waterline

D = propeller diameter

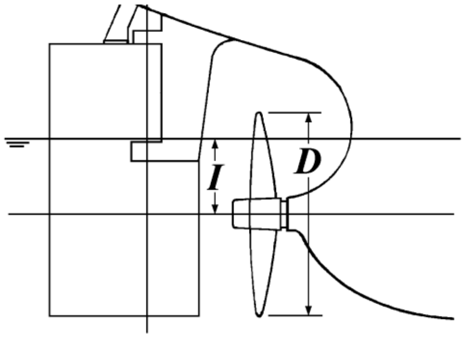
(b) In the application of the provisions of **(a)** above, where two or more pairs of these tanks are intended to be partially filled, filling levels of all other wing ballast tanks are to be considered between empty and full.

(c) In the application of the provisions of **(a)** above, the maximum and minimum filling levels of the above mentioned pairs of side ballast tanks are to be indicated in the loading manual specified in **25.1.2, Part CS of the Rules**.

(7) The provisions of **(4)** to **(6)** above need not apply to ballast water exchange using the sequential method. However, bending moment and shear force calculations for each de-ballasting or ballasting stage in the ballast water exchange sequence are to be included in the loading manual or ballast water management plan of any vessel that intends to employ the sequential ballast water exchange method.

(8) For the application of the provisions of **(4)** to **(6)** above, reference is to be made to **Annex 4.3, Part 1, Part C of the Rules**.

Fig. CS15.2.1-1 Propeller Immersion



CS15.2.3 Calculation of Section Modulus of Transverse Section of Hull

1 Unit of section modulus of transverse section of hull

The section modulus Z (cm^3) is to have five significant figures.

2 Members included in longitudinal strength

The ratio of inclusion of members effective for longitudinal strength is to be as follows.

(1) All intercostal plates may be included if the fillet welding complies with **12.2.1.3-2, Part 1, Part C of the Rules**.

(2) All doubling plates may be included if fitted during ship construction or 90% if fitted during conversion or addition.

(3) For side stringers, slots for frames are to be deducted.

(4) Scallops complying with the following conditions need not be deducted from the sectional area. (*See* **Fig. CS15.2.3-1**)

(a) d_s not exceeding $d/4$ nor exceeding $7t$, maximum 75 mm

(b) S more than $5b$ and more than $10d_s$

(5) As for the longitudinal continuous decks between hatchways of ships having 2 or 3 rows of cargo hatches, the ratio of sectional area to be included in the calculation of the section modulus is to be obtained from **Table CS15.2.3-1**. For intermediate values of ξ and l/L, linear interpolation is to be applied.

(6) Where the sectional area of longitudinals, which are unable to be continued due to factors such as the arrangement of small hatch openings are compensated by adjacent ones, they may be included in the calculation of the section modulus of the transverse section.

(7) Where the car deck plating of exclusive car carriers are intermittently welded in lap joints, they are not to be included in the calculation of the section modulus of the transverse section.

Fig. CS15.2.3-1 S, b and d_s of Scallops

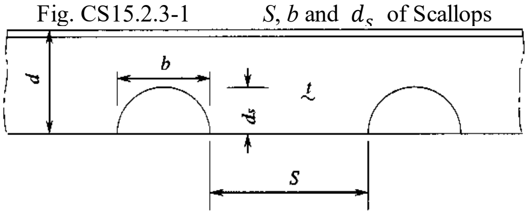


Table CS15.2.3-1 Ratio of Inclusion of Sectional Area

	Hatches in 2 rows			Hatches in 3 or more rows		
ξ	*l/L*					
	0.10	0.20	0.30	0.10	0.15	0.20
0	0.96	0.85	0.70	0.96	0.91	0.85
0.5	0.65	0.57	0.48	0.89	0.80	0.69
1.0	0.48	0.43	0.36	0.83	0.73	0.62
2.0	0.32	0.29	0.25	0.73	0.63	0.53
3.0	0.24	0.22	0.18	0.65	0.57	0.47

Notes:

ξ = Values obtained from the following formula:

$$\frac{ab^3}{lI_c}\left\{\frac{1+2\mu}{6(2+\mu)}\times 10^4+2.6\frac{I_c}{a_c b^2}\right\}$$

Where:

I_c : Moment of inertia (cm^4) of deck between hatches, including hatch coamings

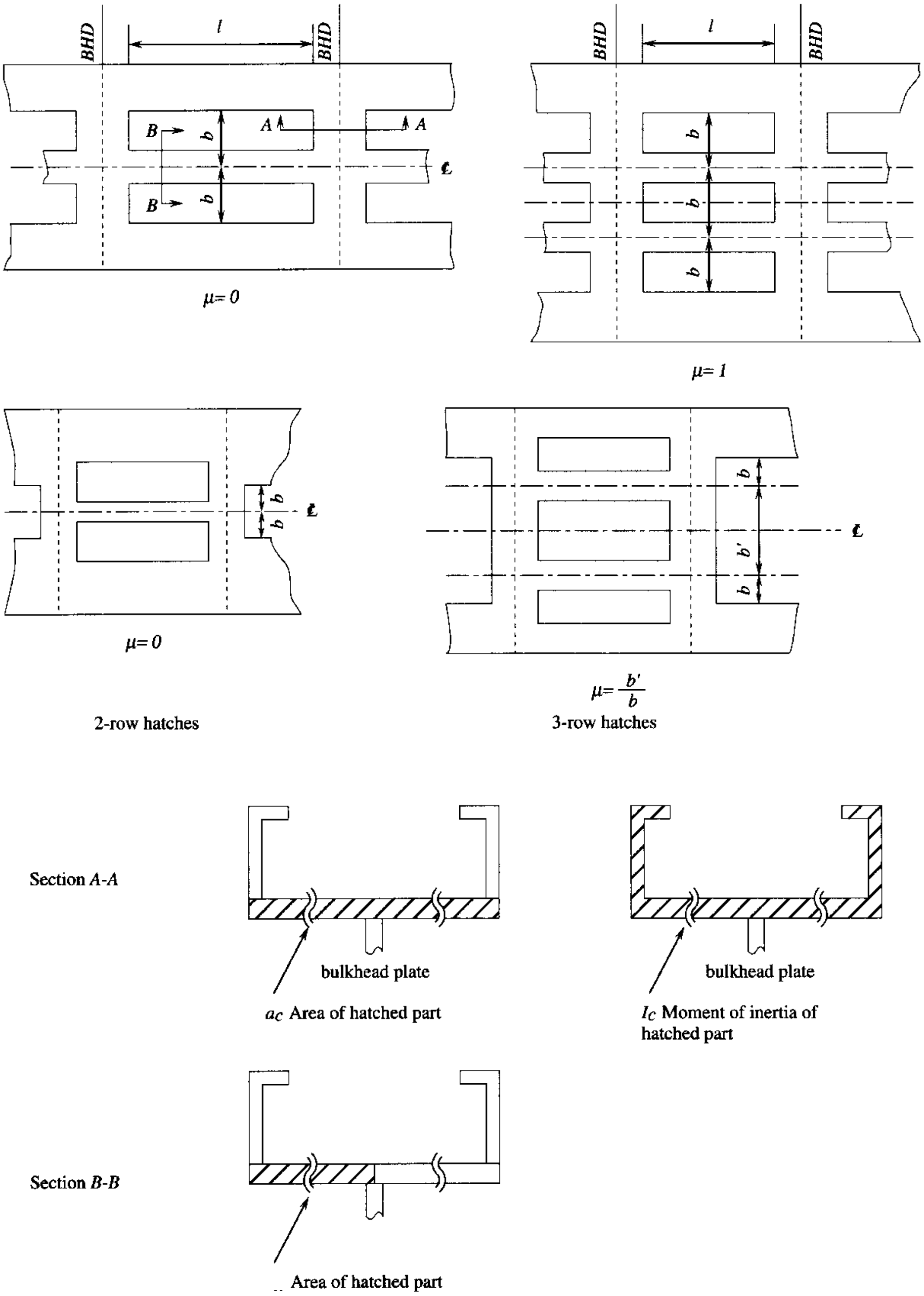
a_c: Effective shear area (cm^2) of deck between hatches

a : Sectional area (cm^2) of continuous deck between hatches (port or starboard side half)

l : Length (m) of hatch

μ , b : As per **Fig. CS15.2.3-2** (m)

Fig. CS15.2.3-2. l, b and μ



3 Openings in strength decks

Openings in strength decks outside the line of hatch openings are to be treated as mentioned below.

(1) Where the shape and dimensions do not meet the conditions in **Table CS15.2.3-3**, reinforcement by means of rings, thicker plates, etc. is required (*See* **Fig. CS15.2.3-3** and **Fig. CS15.2.3-4**)

(2) Where the intervals between centres of holes e do not meet the conditions in **Fig. CS15.2.3-5**, reinforcement as per **(1)** above is needed.

Table CS15.2.3-3

	Elliptic holes	Circular holes
Oil tankers	$\frac{a}{b} \leq \frac{1}{2}, a \leq 0.06B$ $(a_{max} = 900\ mm)$	$a \leq 0.03B$ $(a_{max} = 450\ mm)$
Cargo ships	$\frac{a}{b} \leq \frac{1}{2}, a \leq 0.03(B - b_H)$ $(a_{max} = 450\ mm)$	$a \leq 0.015(B - b_H)$ $(a_{max} = 200\ mm)$

Fig. CS15.2.3-3 Where Elliptic Hole and Circular Hole are in Same Cross-section

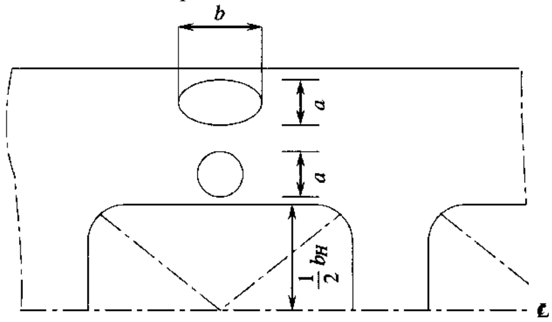


Fig. CS15.2.3-4 Reinforcement by Means of Ring

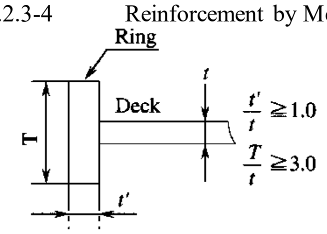
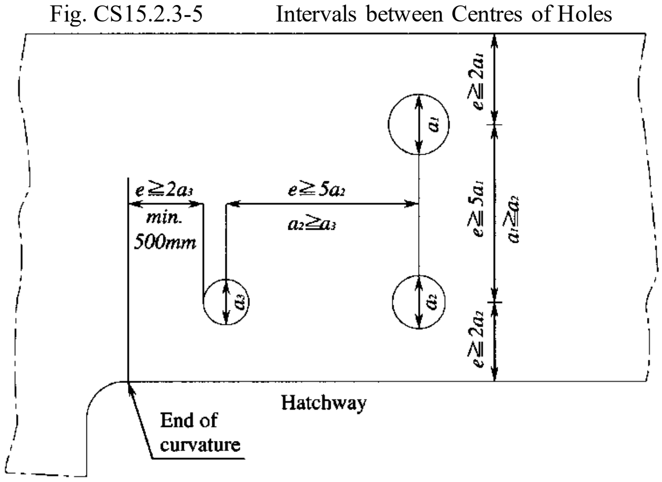


Fig. CS15.2.3-5 Intervals between Centres of Holes



CS16 PLATE KEELS AND SHELL PLATING

CS16.3 Shell Plating for Midship Part of Ship

CS16.3.3 Sheer Strakes

Precautions regarding sheer strakes

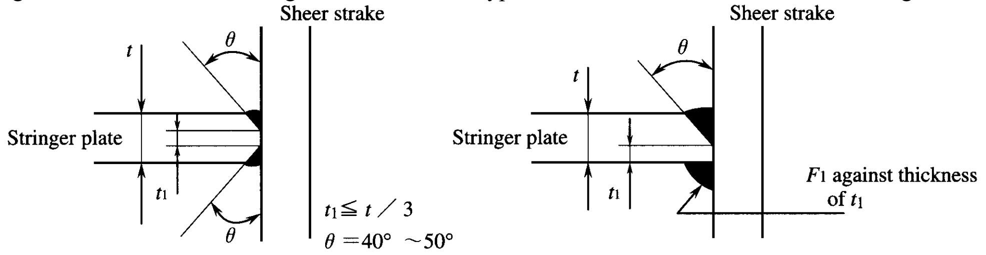
(1) The upper edges of sheer strakes are to be properly smoothed.

(2) Bulwarks are not to be directly welded to sheer strakes in the range of 0.6*L* amidships. Furthermore, fixtures such as eye plates are not to be directly welded on to the upper edge of sheer strakes, except in the fore and aft end parts.

(3) Special care should be taken where fixtures, gutter bar ends, etc. are directly welded on to the curved parts of round gunwales.

(4) At least for 0.6*L* amidships, the standard manner of welding construction of T-type joints between sheer strakes and stringer plates of the strength deck is to be as shown in **Fig. CS16.3.3-1**. However, where the thickness of stringer plates is less than 13 *mm*, fillet welds of F_1 grade may be acceptable without edge preparation.

Fig. CS16.3.3-1 Welding Construction of T-type Joints between Sheer Strakes and Stringer Plates



CS16.4 Shell Plating for End Parts

CS16.4.1 Shell Plating for End Parts

1 The thickness of shell plating of curved parts within 0.3 *L* from the forward and aft end may be calculated with the value of *S* taken as equal to 1.1 *times* the vertical or horizontal distance between frames *a* (*See* **Fig. CS16.4.1-1**)

2 The thickness of shell plating is to be tapered as shown in **Fig. CS16.4.1-2**.

The thickness of each strake is not to be less than the thickness shown in **Fig. CS16.4.1-2** approximately at the middle of length of each plate.

Fig. CS16.4.1-1 Relation of *S* and *a* in End Parts

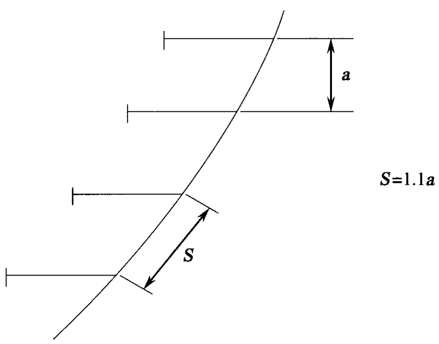
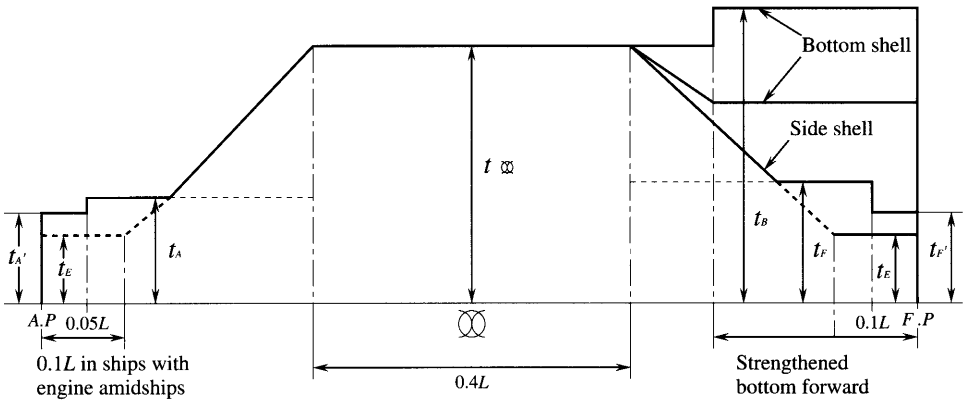


Fig. CS16.4.1-2 Tapering of Shell Plating Thickness



Notes:

t⨂ : Required thickness (mm) of shell plating in midship part (to be the actual thickness, if actual thickness is greater than required due to assuring the longitudinal strength)

t_E: Required thickness of shell plating in end parts

$(5.6 + 0.044L)$ (mm)

$t_F(t'_F)$: Required thickness of shell plating within 0.3 L from the fore end

$(1.34S\sqrt{L} + t_c)$ (mm)

$t_A(t'_A)$: Required thickness of shell plating within 0.3 L from the aft end

$(1.20S\sqrt{L} + t_c)$ (mm)

t_B: Required thickness (mm) of shell plating in the strengthened bottom forward

CS16.4.4 Shell Plating of Bottom Forward

1 In ships of which C_b is not more than 0.7 and $V/\sqrt{L}$ is not less than 1.4, the thickness of shell plating at the strengthened bottom forward specified in **CS6.9.2** is to be determined in accordance with **16.4.4, Part CS** of the Rules using P in **CS6.9.1-2(2)(a)**.

CS16.5 Side Plating in way of Superstructure

CS16.5.3 Compensation at Ends of Superstructure

The manner of construction at the ends of superstructures is to be as shown in **Fig. CS16.5.3-1** or **Fig. CS16.5.3-2**.

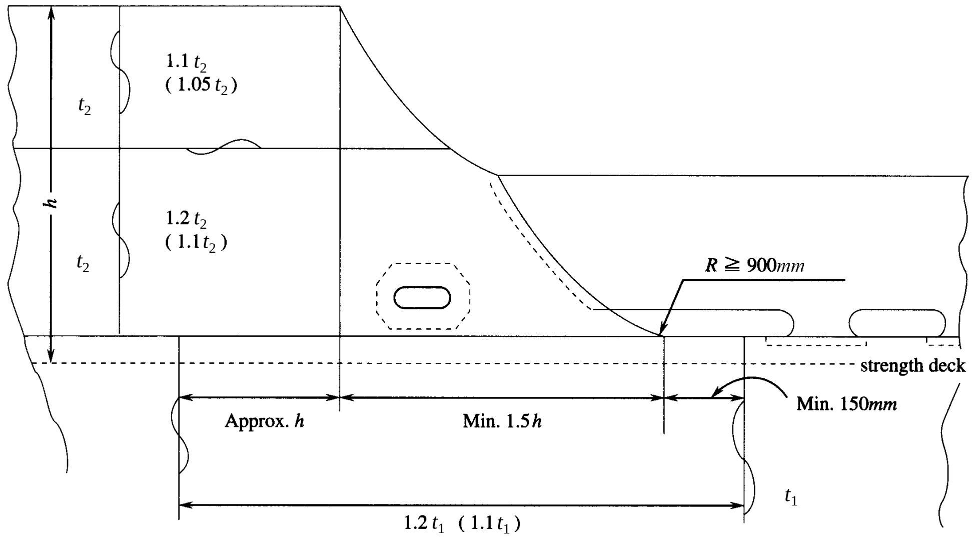
(1) The side shell plating of the superstructure is to be well extended beyond the end of the superstructure to terminate with an ample radius ($R \geq 900$ mm).

(2) Butt welding joints of sheer strakes at the strength deck is to be off by at least 150 mm from the R-end.

(3) The rate of thickening of shell plating in the region of 0.4L amidships is to be as shown in **Fig. CS16.5.3-1** and **Fig. CS16.5.3-2** (even when an expansion joint is not provided, the rate of thickening is to be the same). The rate of thickening is to be zero in the region 0.2L from the fore and aft ends of the ship. At intermediate points, the rate is to be determined by linear interpolation.

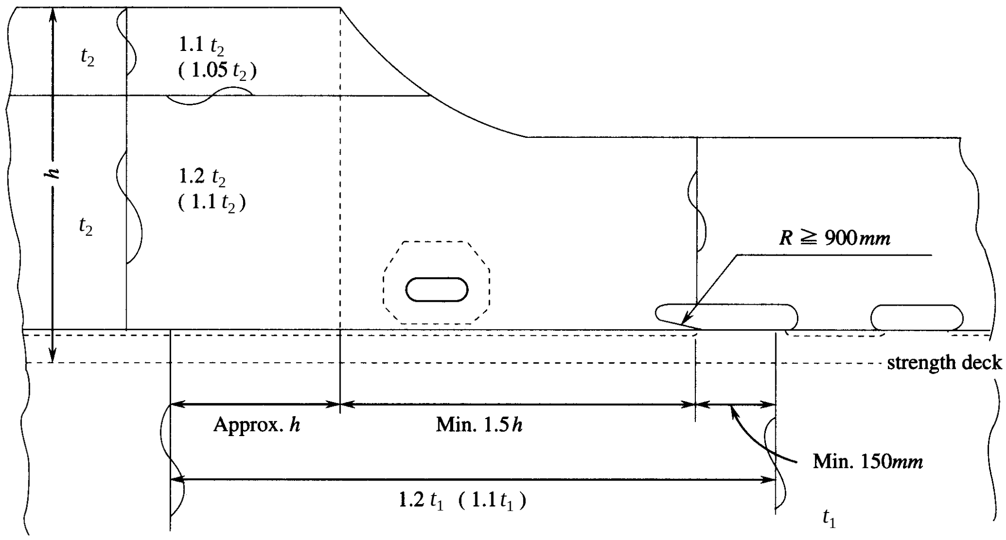
(4) Where the superstructure is set in, no thickening of shell plating is needed.

Fig. CS16.5.3-1 Construction at the End of Superstructure (With Expansion Joint)



Notes:
1. t_1 = Thickness of sheer strake
2. t_2 = Thickness of superstructure side plating
3. Figures without brackets ( ) show the case where the superstructure deck is regarded as the strength deck.
4. Figures in brackets ( ) show the case where the superstructure deck is not the strength deck.

Fig. CS16.5.3-2 Construction at the End of Superstructure (Without Expansion Joint)



Notes: For symbols, the **Notes** to **Fig. C16.6.1-1** are to be referred to.

CS16.6 Local Compensation of Shell Plating

CS16.6.1 Openings in Shell

Compensation for openings

(1) Openings in shell plating of 300 *mm* or more in size are to be compensated by doubling plate or by thickening of the plate.

(2) In the end parts of the hull, proper modifications may be accepted in regards to the compensation for openings.

(3) The radius at the corners of openings is to be at least 100 *mm*.

CS16.6.2 Recesses

Refer to **CS16.6.1** for compensation of openings.

CS17 DECKS

CS17.1 Value of Deck Load *h*

CS17.1.1 Value of *h*

Suitable documents which specify values of the deck load *h* (kN/m^2) prescribed in **17.1.1-1, Part CS** of the Rules (e.g. Loading Manual) are to be provided on board to aid the ship's master.

CS17.2 General

CS17.2.1 Steel Deck Plating

1 Decks which are not fully plated

(1) Stringer plates

Decks not fully plated are to have stringer plates of an appropriate breadth and of a thickness not less than that determined for deck plating in accordance with the requirements in **17.4, Part CS** of the Rules for the positions concerned. The stringer plates of effective decks are to be effectively connected to the shell plating.

(2) Tie plates

Tie plates are to be provided along hatch sides, in way of pillars, on the under-deck girders and under deckhouse coamings. These tie plates are to have an appropriate breadth and a thickness not less than that determined for deck plating in accordance with the requirements in **17.4, Part CS** of the Rules for the positions concerned.

(3) In way of transverse bulkheads and at the ends of deck openings

In way of transverse bulkheads and at the ends of deck openings, the deck is to be suitably plated with steel plates.

2 Wooden decks

(1) Materials

(a) The materials of wooden deck planking are to be of a good quality well seasoned and without rots, saps, cracks and defective knots.

(b) The term "hard wood" means materials such as teak, and the term "soft wood" those such as cedar.

(2) Scantlings of wooden deck planking

Deck planks are to be effectively arranged and fixed, and their thickness is not to be less than 63 *mm* for soft wood and 50 *mm* for hard wood. The thickness may be suitably reduced in spaces appropriated for living accommodation and navigation works only.

CS17.2.2 Watertightness of Decks

1 Where the rudder stock penetrates the deck lower than 1.5 *m* above the load line, special attention is to be given to the watertightness at the penetration.

2 With respect to the provisions of **17.2.2-2, Part CS** of the Rules, decks required to be watertight are to be in accordance with following **(1)** and **(2)**.

(1) Deck structures are to comply with related provisions of **Chapter 13, Part CS** of the Rules for the pressure due to head of water in the most severe conditions at the intermediate or final stages of flooding specified in **Chapter 4, Part CS** of the Rules. In this case, such decks are to be regarded as the part of the deck which forms bulkhead recesses.

(2) Where the trunks and other constructions penetrating watertight deck are provided, such trunks are to be capable of withstanding the pressure due to a head of water up to the bulkhead deck and head of water in the most severe conditions at the intermediate or final stages of flooding specified in **Chapter 4, Part CS** of the Rules.

CS17.2.4 Compensation for Openings

1 All corners of openings in decks, such as hatchways, are to be well rounded, properly smoothed and reinforced, as necessary, by thickening the deck plating or by means of doubling plates.

(1) Regions where thicker plating or doubling plates are required

Strength deck: Within 0.75L ⊗

Effective 2nd deck: Within 0.6L ⊗

3rd deck and lower decks: No doubling needed, as a rule

Superstructures and long deckhouse:

Doubling within 0.6L ⊗ for decks immediately above the strength deck

(2) Plate thickening and doubling plates may be properly reduced depending upon their locations. (*See* **Fig. CS17.2.4-1**)

(3) The dimensions and thickness of doubling plates or ranges of thickening are to be determined considering the degree of stress concentration around the openings.

(4) The minimum radii at the corners are to be as follows:

Within 0.5L ⊗ of strength deck: 250 *mm*

Elsewhere: 200 *mm*

The radius may be suitably reduced for small openings. For companionways and similar small openings, the radius at the corners may be 150 *mm* in the strength deck outside the line of openings and 75 *mm* or so elsewhere.

(5) For corners of openings having a radius not less than 600 *mm* or having a parabolic or similar shape, neither doubling plates nor thickening of the plating is required. The recommended corner shape is as shown in **Fig. CS17.2.4-2**.

(6) No welded joints are permitted at the corners of openings in the strength deck. The welded joints are to be properly off the end of the curvature. (*See* **Fig. CS17.2.4-3**)

Fig. CS17.2.4-1

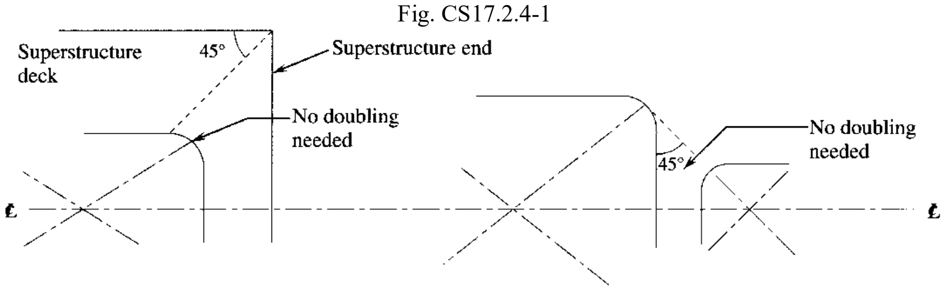


Fig. CS17.2.4-2

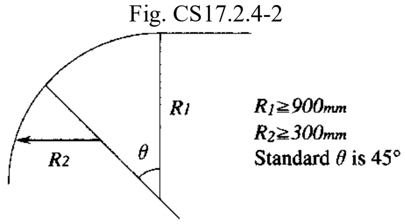
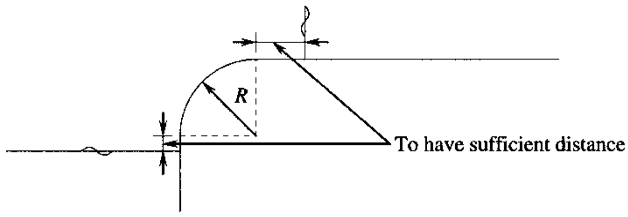
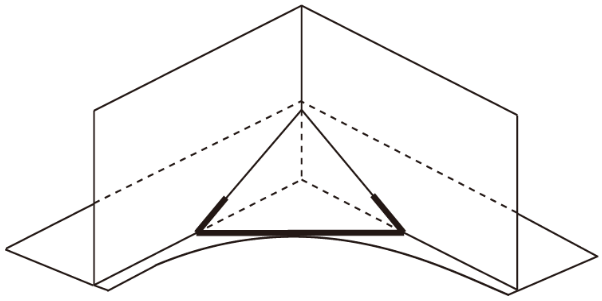


Fig. CS17.2.4-3



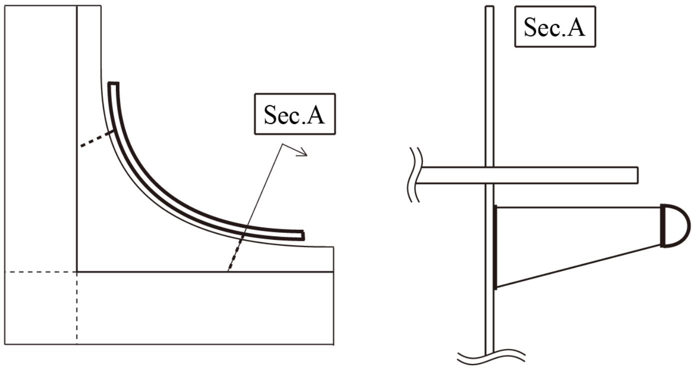
2 Where attachments such as slant plates or protective means are provided as stated in **17.2.4-2, Part CS of the Rules**, such attachments are to be provided as referred to the method shown in **Fig. CS17.2.4-4** or **Fig. CS17.2.4-5**.

Fig. CS17.2.4-4 Example of the Method for Providing Slant Plates



Note:
The connections between slant plates and strength deck (indicated in the bold line) are not to be welded.

Fig. CS17.2.4-5 Example of the Method for Providing Protective Means



Note:
Protective means (i.e. half round bars) are to be provided on hatch side girders and hatch end beams.

CS17.2.5 Rounded Gunwales

Where rounded gunwales are made of steel plate of Grade *D* or Grade *E*, the inner radius of the curvature is not to be less than 20 *times* the thickness of the gunwale plate. However, where the width of the sheer strake that is bent to form the rounded gunwale is not less than 500 *mm* plus the plate width of the strake prescribed in **3.2.2.1-4, Part 1, Part C of the Rules** or the method of bending work is especially approved by the Society, the radius may be reduced down to 15 *times* the plate thickness.

CS17.3 Effective Sectional Area of Strength Deck

CS17.3.2 Effective Sectional Area of Strength Deck

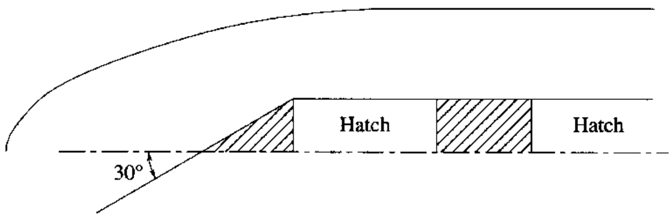
1 Members to be included in the calculation of the actual sectional area of strength deck

In addition to the deck plating, members attached to the deck plating, such as stringer angles and longitudinal beams, which are included as longitudinal strength members are to be included in the calculation of the actual sectional area. The shaded areas in the figure below are not to be included in the calculation. (*See* **Fig. CS17.3.2-1**)

2 Where round gunwales are provided, the sectional area is to be calculated assuming that the plate of the round gunwale is horizontally extended to the ship's side.

3 In the requirements of **17.3.2-3, Part CS** of the Rules, "the value approved by the Society" means the value obtained by applying the provisions of **15.2.1-1, Part CS of the Rules** by using the coefficient C_2 obtained from the dotted line in **Fig. CS15.1, Part CS of the Rules**.

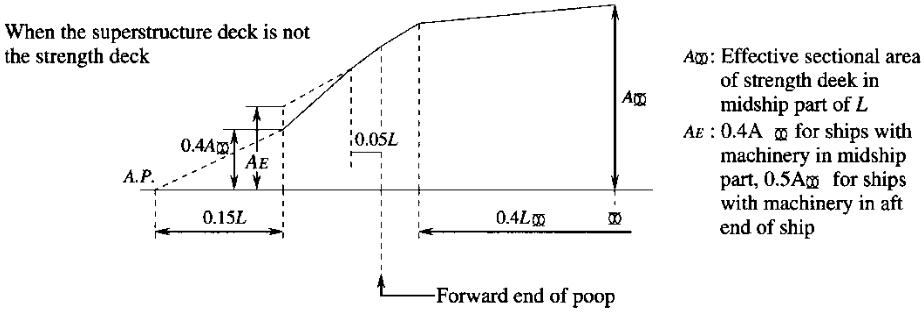
Fig. CS17.3.2-1



CS17.3.4 Effective Sectional Area of Strength Deck within Long Poop

When the superstructure deck is not the strength deck (*See* **Fig. CS17.3.4-1**)

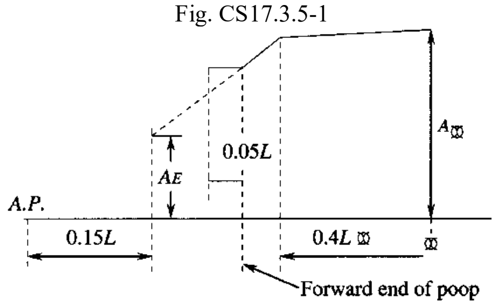
Fig. CS17.3.4-1



CS17.3.5 Deck within Superstructure where Superstructure Deck is Designed as Strength Deck

In case of poop deck (*See* **Fig. CS17.3.5-1**)

Fig. CS17.3.5-1



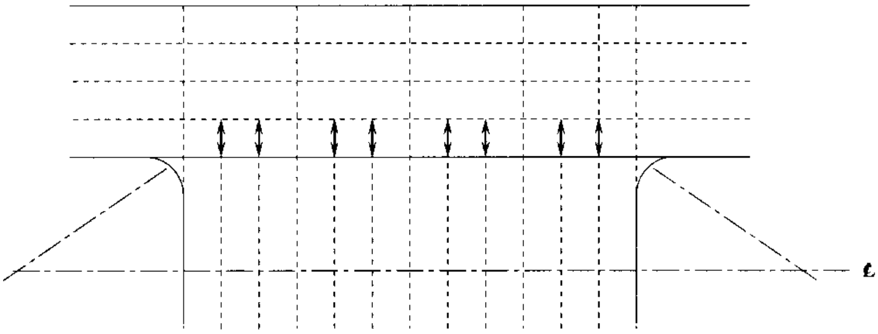
$A_{⊠}$ and A_E are as specified in **Fig. C17.2.4-1**

CS17.4 Deck Plating

CS17.4.1 Thickness of Deck Plating

For prevention of deck buckling, the deck within the line of openings is recommended to be constructed using the transverse framing system. (*See* **Fig. CS17.4.1-1**)

Fig. CS17.4.1-1



CS17.4.5 Thickness of Deck Plating Loaded with Wheeled Vehicles

The thickness of deck plating loaded with wheeled vehicles is to be determined according to **(1)** or **(2)** below. The thickness of plating of the weather deck is to be 1 *mm* thicker than that obtained from these formulae.

(1) Where the distance between the centres of wheel prints in a panel is not less than $(2S + a)$:

$$C\sqrt{\frac{2S-b'}{2S+a}\cdot\frac{P}{9.81}}+1.5\ \ (mm)$$

Where:

C: Coefficient obtained from **Table CS17.4.5-1**

S: Beam spacing (m)

P: Maximum designed wheel load (kN), or, if $b > S$, a value equal to the maximum designed wheel load multiplied by the value of S/b

Where the maximum designed wheel load is given in tons, the value of P should be multiplied by 9.81 to convert it into kN.

b' : b or S, whichever is the smaller

a and b : Dimensions of wheel print as shown in **Fig. CS10.7.1-1**

However, for vehicles with ordinary pneumatic tires, values of a and b in **Table CS10.7.1-1** may be used.

(2) Where the distance between centres of wheel prints in a panel is less than $(2S + a)$ (*See* **Fig. CS17.4.5-1**):

$$C\sqrt{\frac{2S-b'}{2S+a+e}\cdot\frac{nP}{9.81}}+1.5\ \ (mm)$$

Where:

C, S, a, b' and P: As specified in **(1)** above

e: Sum of distances (m) between centres of wheel prints where wheels are placed side by side at a spacing of less than $(2S + a)$ in one panel (*See* **Fig. CS17.4.5-1**)

n: Number of wheel loads in the range of e

Fig. CS17.4.5-1 Measurement of e

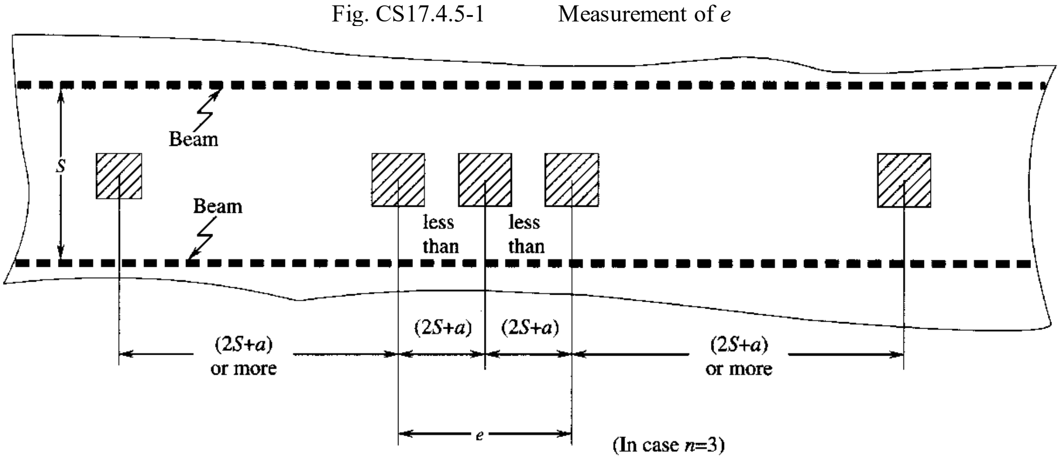


Table CS17.4.5-1 Values of C

		Vehicles exclusively used for cargo handling	Other vehicles
Midship part of strength deck	Longitudinal framing	$4.6\sqrt{K}$	$\frac{3.64\sqrt{K}}{\sqrt{1-0.64f_{DH}K}}$
	Transverse framing	$4.9\sqrt{K}$	$\frac{5.15\sqrt{K}}{\sqrt{1-0.41{f_{DH}}^2K^2}}$
Elsewhere		$4.6\sqrt{K}$	$5.2\sqrt{K}$

Note:

f_{DH}: Value as specified in **CS10.7.1-1**

In longitudinal framing system, f_{DH} is not to be less than 0.79/K.

CS18 SUPERSTRUCTURES AND DECKHOUSES

CS18.1 General

CS18.1.1 Application

With respect to the provisions of **Chapter 18, Part CS of the Rules**, the determination of the position of tiers above the freeboard deck may be treated in the same manner as the provisions of **CS1.1.3-2(2)(c)**.

CS18.3 Closing Means for Access Openings in Superstructure End Bulkheads

CS18.3.1 Closing Means for Access Openings

Where the sill of an access opening is liable to hinder the passage of heavy spare parts or similar, a portable sill may be used subject to approval by the Society under the following conditions.

(1) Portable sills are to be installed before the ship leaves port.

(2) Portable sills are to be gasketed and fastened by closely spaced through-bolts.

(3) Whenever sills are replaced after removal, the weathertightness of the sills and relevant doors is to be verified by hose testing. The dates of removal, replacement and hose testing are to be recorded in the ship's log-book.

CS18.4 Additional Requirements for Bulk Carriers, Ore Carriers and Combination Carriers, etc.

If this requirement 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 length for freeboard defined in **2.1.3, Part A of the Rules**.

CS19 HATCHWAYS, MACHINERY SPACE OPENINGS AND OTHER DECK OPENINGS

CS19.1 General

CS19.1.2 Position of Exposed Deck Openings

1 In the application of the requirements of **19.1.2, Part CS** of the Rules, "superstructure decks" include top decks of superstructures, deckhouses, companionways and other similar deck structures.

2 "Exposed raised quarter decks" in the definition of Position I specified in **19.1.2, Part CS** of the Rules refers to exposed superstructure decks lower than h_S specified in **V2.2.1** above the freeboard deck.

3 "Exposed superstructure decks" in the definition of Position I specified in **19.1.2, Part CS** of the Rules refers to exposed superstructure decks lower than $2h_S$ specified in **V2.2.1** above the freeboard deck.

4 "Exposed superstructure decks located at least one standard height of superstructure above the freeboard deck" in the definition of Position II specified in **19.1.2, Part CS** of the Rules refers to exposed superstructure decks located at least h_S specified in **V2.2.1** above the freeboard deck and lower than $2h_S$ specified in **V2.2.1** above the freeboard deck.

5 "Exposed superstructure decks located at least two standard heights of superstructure above the freeboard deck" in the definition of Position II specified in **19.1.2, Part CS** of the Rules refers to exposed superstructure decks located at least $2h_S$ specified in **V2.2.1** above the freeboard deck and lower than $3h_S$ specified in **V2.2.1** above the freeboard deck.

CS19.2 Hatchways

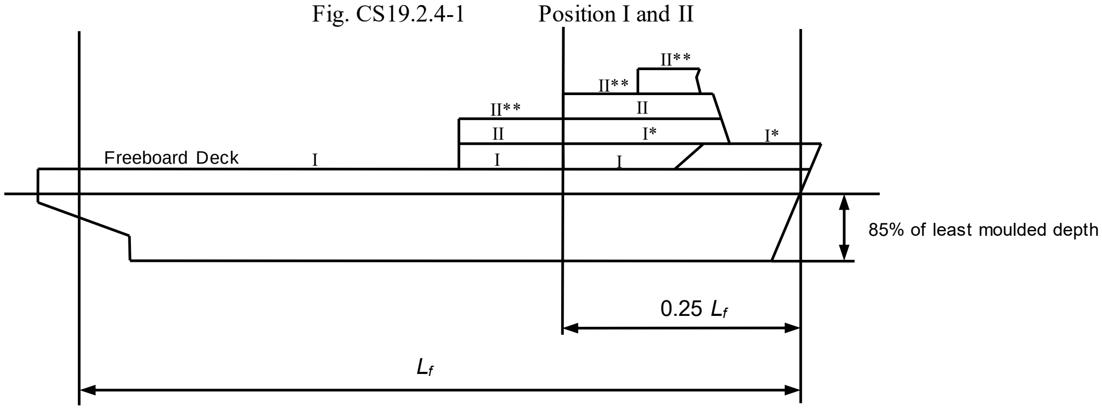
CS19.2.4 Design Loads for Steel Hatch Covers, Portable Beams and Hatchway Coamings

1 Design vertical wave load P_{HC} as specified in **19.2.4(1), Part CS** of the Rules is to comply with the following requirements.

(1) Positions I and II may be determined in accordance with **Fig. CS19.2.4-1** and **-2**.

(2) Where an increased freeboard is assigned, the design load for hatch covers according to **19.2.4(1), Part CS** of the Rules on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to one superstructure standard height (as per Regulation 33 of the "*International Convention on Load Lines,* 1966 *and Protocol of* 1988 *relating to the International Convention on Load Lines,* 1966") below the actual freeboard deck (see **Fig. CS19.2.4-2**).

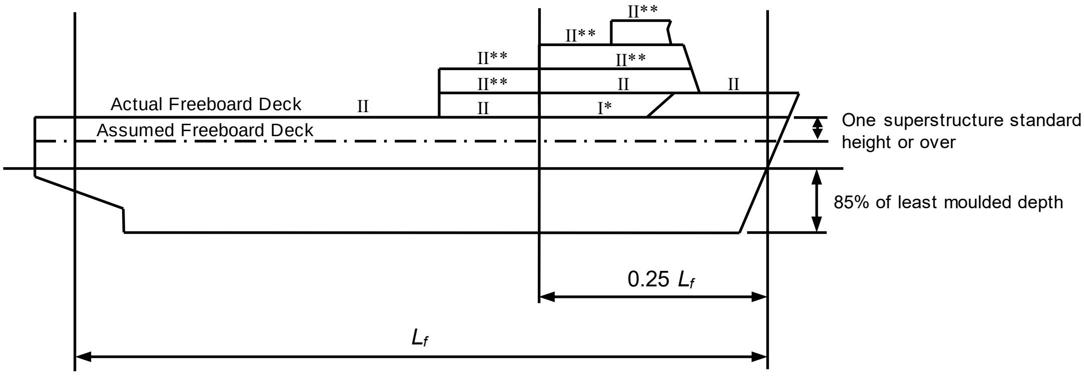
Fig. CS19.2.4-1 Position I and II



* Exposed superstructure decks located at least one superstructure standard height above the freeboard deck

** Exposed superstructure decks of vessels having length L_f of greater than 100m located at least one superstructure standard height above the lowest Position II deck

Fig. CS19.2.4-2 Position I and II for an Increased Freeboard

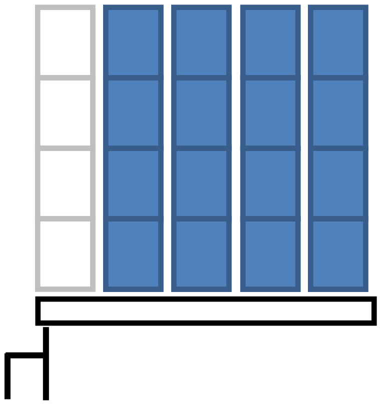
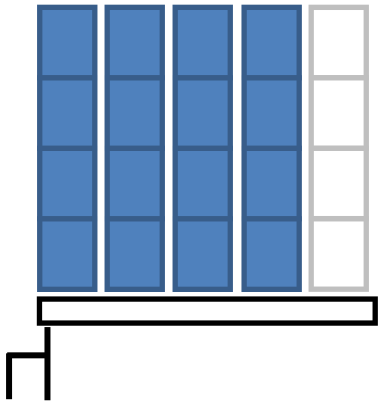
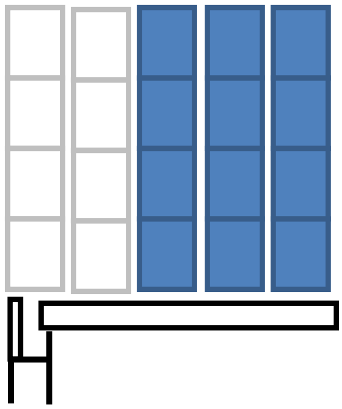
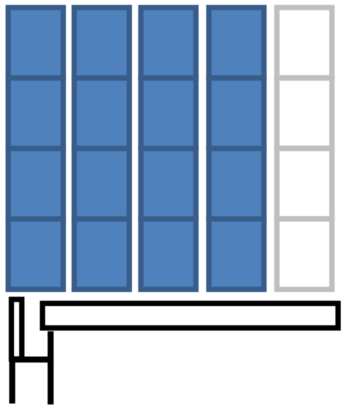
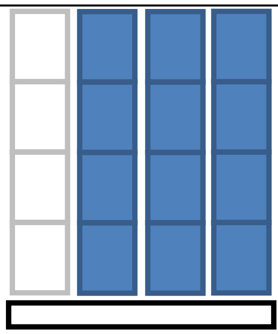
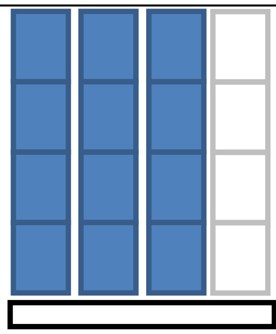


* Exposed superstructure decks located at least one superstructure standard height above the freeboard deck

** Exposed superstructure decks of ships having length L_f of greater than 100*m* located at least one superstructure standard height above the lowest Position II deck

2 In the application of the requirements of **19.2.4(4)(a)** and **(c), Part CS** of the Rules, load cases with the partial loading of containers on hatch covers are to be considered (see **Fig. CS19.2.4-3**). However, where deemed necessary by the Society, load cases other than those specified in **Fig. CS19.2.4-3** are to be separately considered.

Fig. CS19.2.4-3 Partial Loading of Containers on Hatch Covers

Heel direction		
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (centre hatch covers)		

3 The partial load cases specified in **Fig. CS19.2.4-3** may not cover all partial load cases critical for the hatch cover lifting specified in **19.2.10-2, Part CS of the Rules**.

4 In the case of mixed stowage (e.g., 20-*foot* + 40-*foot* container combined stacks), the foot point forces at the fore and aft ends of the hatch cover are not to be higher than those resulting from the design stack weight for the 40-*foot* containers, and the foot point forces at the middle of the cover are not to be higher than those resulting from the design stack weight for the 20-*foot* containers.

CS19.2.10 Closing Arrangements

"At the discretion of the Society" prescribed in **19.2.10-2, Part CS** of the Rules refers to the following case:

(1) The case in which the height h_E (mm) of the transverse cover guides above the hatch cover supports is not less than that obtained from the following formula (see **Fig. CS19.2.10-1**):

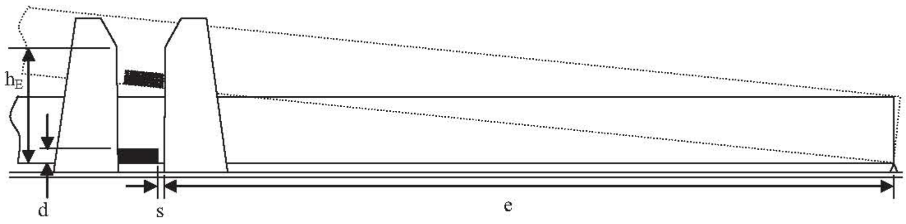
$h_E = 1.75\sqrt{2se + d^2} - 0.75d$, however, in no case is h_E to be less than the height of the cover edge plate plus 150 mm.

e: Largest distance (mm) from the inner edges of the transverse cover guides to the ends of the cover edge plate

s: Total clearance (mm) within the transverse cover guide, with $10 \leq s \leq 40$

d: Distance between the upper edge of transverse stopper and the hatch cover supports

Fig. CS19.2.10-1 Height of Transverse Cover Guides



CS19.2.12 Steel Hatchway Covers for Container Carriers

1 In the application of the requirements of **19.2.12, Part CS** of the Rules, the height of coamings above the upper surface of the deck where the hatchway covers are fitted is to be at least 600 *mm*.

2 In the application of the requirements of **19.2.12-1, Part CS** of the Rules, the following requirements **(1)** through **(4)** are to be complied with:

(1) The hatchway covers concerned may be fitted to hatchways located on weatherdecks which are at least two standard superstructure heights (as per Regulation 33 of the "*International Convention on Load Lines*, 1966") above an actual freeboard deck or an assumed freeboard deck from which the freeboard can be calculated which will result in a draught not less than that corresponding to the freeboard actually assigned. Where any part of a hatchway is forward of a point located one quarter of the ship's length ($0.25L_f$) from the forward perpendicular, that hatchway is to be located on a weatherdeck at least three standard superstructure heights above the actual or assumed freeboard deck.

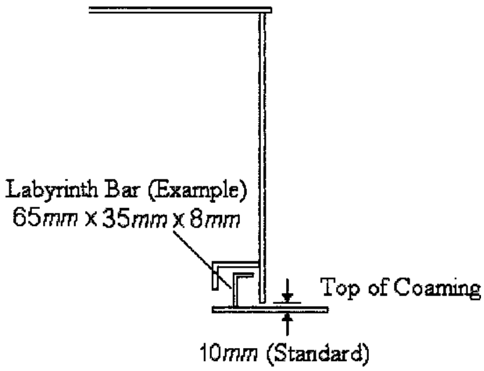
(2) The non-weathertight gaps between hatch cover panels are to be considered as unprotected openings in the application of **Part U** and **Chapter 4, Part CS** of the Rules. They are to be as small as possible commensurate with the capacity of the bilge system and expected water ingress, and the capacity and operational effectiveness of the fixed gas fire-extinguishing system required in **Part R** of the Rules, and are not to be more than 50 *mm*.

(3) Labyrinths, gutter bars, or other equivalent means are to be fitted close to the edges of each panel in way of the gaps to minimize the amount of water that can enter the container hold from the top surface of each panel. In general, the height of such means is not to be less than 65 *mm* from the top of the coaming and gutter bars or from the top of the panel, and the gaps between hatch covers and the top of the coaming are not to exceed 10 *mm*. (See **Fig. CS19.2.12-1**)

(4) Bilge alarms are to be provided in each hold fitted with non-weathertight covers.

3 In the application of **19.2.12-2**, **Part CS** of the Rules, relevant requirements specified in MSC/Circ.1087 may be applied.

Fig. CS19.2.12-1 Arrangement of Labyrinth (Example)



CS19.2.13 Additional Requirement for Small Hatches Fitted on Exposed Fore Decks

1 General

(1) The strength of, and securing devices for, small hatchways fitted on the exposed fore deck in **19.2.13**, **Part CS of the Rules** are to comply with the requirements of this paragraph.

(2) Small hatchways in the context of this requirement are hatchways designed for access to spaces below the deck and are capable of being closed weathertight or watertight, as applicable. Their opening is normally 2.5 m^2 or less.

(3) Notwithstanding the provisions of **(1)** above, hatchways designed for emergency escape need not comply with the requirements of **-3(1)(a)**, **-3(1)(b)**, **-4(3)** and **-5**.

(4) The securing devices of the hatchways for emergency escape are to be of a quick-acting type (e.g., one action wheel handles are provided as central locking devices for latching/unlatching of hatch cover) operable from both sides of the hatch cover.

(5) Small hatchways providing access to cargo holds on container ships need not comply with this **CS19.2.13** (except for **CS19.2.13-2**) in cases where the following **(a)** to **(c)** are satisfied. Such hatch covers fitted at small hatchways are to be treated as non-weathertight regardless of whether they actually are weathertight.

(a) The non-weathertight hatchways are fitted to weather decks which are at least two standard superstructure heights (as per Regulation 33 of the "International Convention on Load Lines, 1966") above an actual freeboard deck or an assumed freeboard deck from which the freeboard can be calculated which will result in a draught not less than that corresponding to the freeboard actually assigned. Where any part of the hatchway is forward of a point located one quarter of the ship's length ($0.25L_f$) from the forward perpendicular, that hatchway is to be located on a weather deck at least three standard superstructure heights above the actual or assumed freeboard deck.

(b) The hatchway coamings are not less than 600 *mm* in height.

(c) Bilge alarms are provided in each hold fitted with non-weathertight hatchways.

2 Strength

(1) For small rectangular steel hatch covers, plate thickness, stiffener arrangement and scantlings are to be in accordance with **Table CS19.2.13-1** and **Fig. CS19.2.13-1**. Stiffeners, where fitted, are to be aligned with the metal-to-metal contact points, required in **-4(1)**. Primary stiffeners are to be continuous. All stiffeners are to be welded to the inner edge stiffener. (See **Fig. CS19.2.13-2**)

(2) For rectangular hatchways, the upper edge of hatchway coamings is to be suitably reinforced by a horizontal section, normally not more than 170 to 190 *mm* from the upper edge of the coamings.

(3) For small hatch covers of a circular or similar shape, the cover plate thickness and reinforcement is to be according to the requirements of the Society.

(4) For small hatch covers constructed of materials other than steel, the required scantlings are to provide equivalent strength.

3 Primary Securing Devices

(1) Small hatchways located on an exposed fore deck subject to the application of this requirement are to be fitted with primary securing devices such that their hatch covers can be secured in place and weathertight by means of a mechanism employing any one of the following methods:

(a) Butterfly nuts tightening onto forks (clamps)

(b) Quick acting cleats

(c) Central locking device

(2) Dogs (twist tightening handles) with wedges are not acceptable.

4 Requirements for Primary Securing Devices

(1) Hatch covers are to be fitted with a gasket of elastic material. This is to be designed to allow metal-to-metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. (See item 9 of **Fig.CS19.2.13-2**) The metal-to-metal contacts are to be arranged close to each securing device in accordance with **Fig.CS19.2.13-1**, and of sufficient capacity to withstand the bearing force.

(2) The primary securing device is to be designed and manufactured such that the designed compression pressure is achieved by one person without the need of any tools.

(3) For a primary securing device that uses butterfly nuts, the forks (clamps) are to be of a robust design. They are to be designed to minimize the risk of the butterfly nuts being dislodged while in use; by means of curving the forks upward, a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks is not to be less than 16 *mm*. An example arrangement is shown in **Fig.CS19.2.13-2**.

(4) For small hatch covers located on an exposed deck forward of the foremost cargo hatch, the hinges are to be fitted such that the predominant direction of green sea force will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

(5) On small hatchways located between the main hatchways, for example between Nos. 1 and 2, the hinges are to be placed on

the fore edge or outboard edge, whichever is practicable for protection from green sea force in beam seas and bow quartering conditions.

5 Secondary Securing Device

Small hatchways on the fore deck are to be fitted with an independent secondary securing device (e.g. by means of a sliding bolt, a hasp or a backing bar of slack fit) which is capable of keeping the hatch cover in place, even in the event that the primary securing device becomes loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

Table CS19.2.13-1 Scantlings for Small Steel Hatch Covers on the Fore Deck

Nominal size ($mm \times mm$)	Cover plate thickness (mm)	Primary stiffeners	Secondary stiffeners
		Flat Bar ($mm \times mm$); number	
630 × 630	8	-	-
630 × 830	8	100 × 8 ; 1	-
830 × 630	8	100 × 8 ; 1	-
830 × 830	8	100 × 10 ; 1	-
1030 × 1030	8	120 × 12 ; 1	80 × 8 ; 2
1330 × 1330	8	150 × 12 ; 2	100 × 10 ; 2

Fig. CS19.2.13-1 Arrangement of Stiffeners

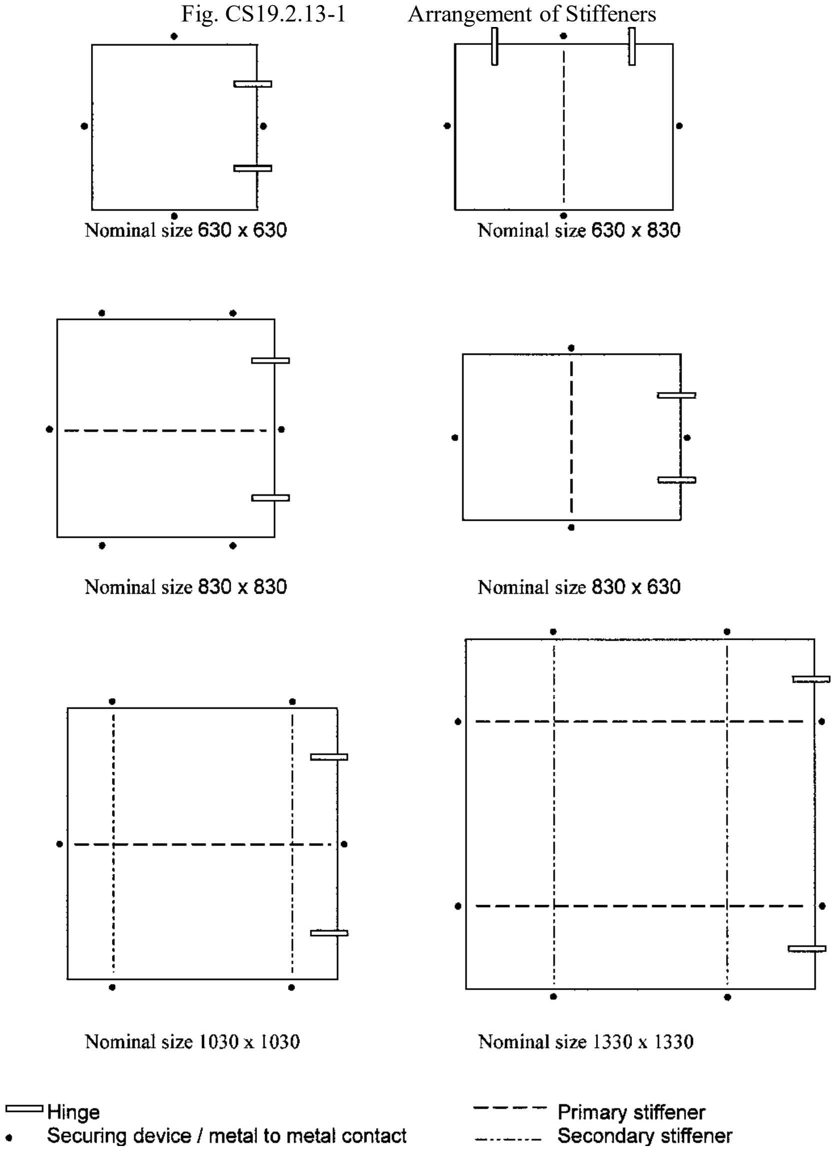
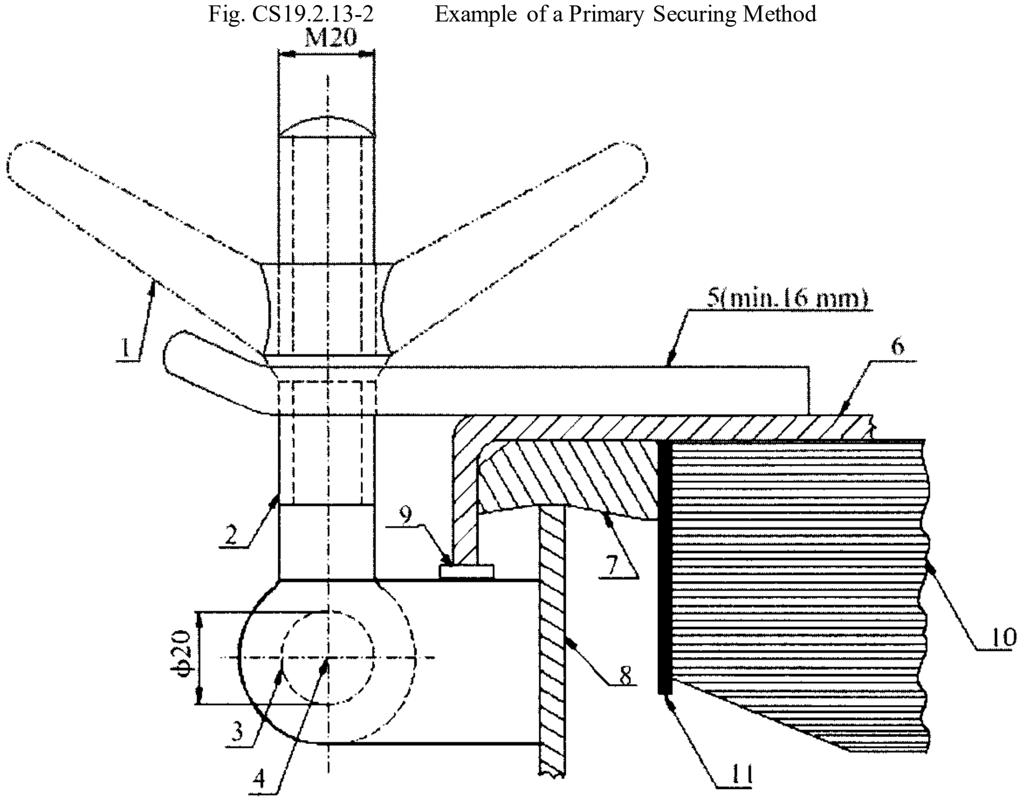


Fig. CS19.2.13-2 Example of a Primary Securing Method



(Note : Dimensions in millimeters)

1. Butterfly nut
2. Toggle Bolt
3. Toggle bolt pin
4. Center of toggle bolt pin
5. Fork(clamp) plate
6. Hatch cover
7. Gasket
8. Hatch coaming
9. Bearing pad welded on the bracket of a toggle bolt for metal to metal contact
10. Stiffener
11. Inner edge stiffener

CS19.3 Machinery Space Openings

CS19.3.5 Miscellaneous Openings in Machinery Casings

In applying the requirements of 19.3.5-1, Part CS of the Rules, the ventilator coamings above the upper surface of the deck is to extend more than 4.5m above the surface of the deck in Position I, and more than 2.3m above the surface of the deck in Position II specified in 19.1.2, Part CS of the Rules. Ventilator openings are not to be fitted with weathertight closing appliances. However, ventilator openings are to be fitted with closing means specified in 19.3.5-3, Part CS of the Rules.

CS19.4 Companionways and Other Deck Openings

CS19.4.2 Companionways

Grouping into deckhouse and companion

(1) A structure is regarded as a deckhouse where its inside is always accessible through access openings provided on the top of the structure or through under-deck passageways, even when all access openings in the boundary walls are closed.

(2) A structure is regarded as a companion where its inside is not accessible through any other way, when all access openings in the boundary walls are closed.

CS20 MACHINERY SPACES, BOILER ROOMS AND TUNNEL RECESSES

CS20.1 General

CS20.1.2 Construction

Sectional area of face plates of web frames in machinery spaces is to be bigger than the value obtained from following formula. However, scantlings of web frames may be determined by other suitable calculation approved by the Society.

$$\frac{8KlSL}{d_W} - \frac{d_W t_W}{600} \ (cm^2)$$

Where:

K : Coefficient obtained in following formula

In case that P is equal to C and over: $1+0.4(1.36P/C-1)$

In case that P is less than C: $1+0.2(1.36P/C-1)$

P : Maximum continuous output of main engine (kW)

C : Coefficient obtained in following formula:

In case that ships are 50 m in length and smaller: $10L$

In case that ships are over 50 m: $35L$-1250

l : Vertical distance (m) from the top of inner bottom plating to the top of beams of lowest deck at side of ships

S : Spacing of web frames (m)

L : Length of ships (m)

d_W : Depth (mm) of web plates of web frames

t_W : Thickness (mm) of web plates of web frames

CS20.2 Main Engine Foundations

CS20.2.1 Ships with Single Bottoms

Where spacing of girders beneath main engines is narrow, centre girder may be omitted. However, intercostal plates are recommended to be fitted with along centre line.

CS20.2.2 Ships with Double Bottoms

1 The following method for determining scantlings of double bottom construction in engine rooms is standard. Other methods approved by the Society may be acceptable.

(1) Thickness of centre girders is not to be less than the value obtained from the following formula.

$$5.7 + 0.056L \ (mm)$$

(2) Thickness of side girders and solid floors is not to be less than the value obtained from the following formula.

When the ship is over 100 m in length:

$$6.5 + 0.035L \ (mm)$$

When the ship is not over 100 m in length:

$$0.6\sqrt{L} + 4.0 \ (mm)$$

2 Girder plates beneath seat plates of the main engine are generally to penetrate inner bottom plates. Where they are unable to penetrate, the inner bottom plates are to be suitably thicker than required and rider plates are to be welded with edge preparation. If man holes are provided in girder plates, their number is to be minimized as far as possible.

3 Where main engines are directly installed on to inner bottom plates, the compartments beneath main engines are recommended to be cofferdams. Where they are used as deep tanks, cap nuts, packing, etc. are to be fitted to the foundation bolts in order to keep water/oil-tightness.

CS21 BULWARKS, GUARDRAILS, FREEING ARRANGEMENTS, CARGO PORTS AND OTHER SIMILAR OPENINGS, SIDE SCUTTLES, RECTANGULAR WINDOWS, VENTILATORS AND GANGWAYS

CS21.1 Bulwarks and Guardrails

CS21.1.1 General

In **21.1.1-2(2)**, **Part CS of the Rules**, "measures deemed appropriate by the Society" implies that **(1)** and **(2)** below need to be satisfied.

(1) Stanchions are to be of increased breadth as in **(a)** to **(c)** below, depending on their arrangement. The figure of these stanchions is given in **Fig.CS21.1.1-1**.

(a) At least every third stanchion is to be of increased breadth: $kb_s \geq 2.9b_s$

(b) At least every second stanchion is to be of increased breadth: $kb_s \geq 2.4b_s$

(c) Every stanchion is to be of increased breadth: $kb_s \geq 1.9b_s$

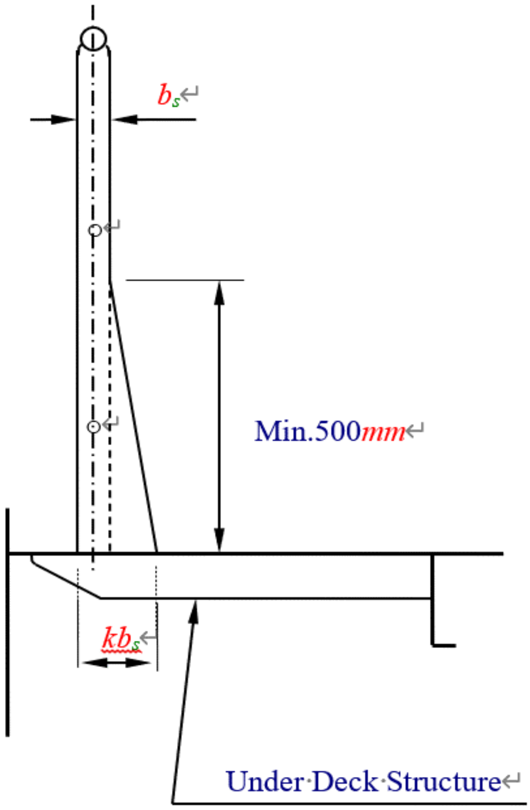
kb_s: increased breadth (*mm*) of stanchion

b_s: breadth (*mm*) of stanchion according to standards approved by the Society

Stanchions of increased breadth are to be welded to the deck with double continuous fillet welds and a minimum leg size of 7 *mm* or as specified by standards approved by the Society.

(2) Stanchions with increased breadth, as described in **(1)** above, are to be aligned with the members below the deck. These members are to be a minimum of 100×12 *mm* flat bar welded to the deck by double continuous fillet welds. The stanchions with increased breadth need not be aligned with under deck structures for deck plating exceeding 20 *mm*.

Fig. CS21.1.1-1 Guardrail Stanchion (Example)



CS21.1.2 Dimensions

Where bulwarks and/or guardrails specified in **21.1.2, Part CS** of the Rules interfere with the ship's normal operation due to their height, the height may be reduced on the condition that suitable alternative protection devices such as portable guardrails are provided.

CS21.1.3 Construction

In cases where the base of a bulwark stay adopts a gusset type, "special consideration" in **21.1.3-4, Part CS of the Rules** means the following **(1)** to **(3)**:

(1) The gusset plate is to be made of steel with the same yield stress as the steel of the upper deck to which the gusset plate is attached.

(2) The toes of gusset plates are to have a soft nose design.

(3) Pad plates are to be provided beneath the gusset plates. In addition, the breadth of such pad plates is to be as narrow as practicable. The pad plates are to be made of steel with the same yield stress as the steel of the upper deck to which the pad plate is attached.

C21.2 Freeing Arrangements

C21.2.1 General

1 The "adequate provisions for freeing the space within superstructures" referred to in **21.2.1-3, Part CS** of the Rules is subject to the following.

(1) The minimum freeing port area on each side of the ship for the open superstructure (A_s) is not to be less than that obtained from the following formula.

$$A_s = \frac{A_1 b_0 h_s}{2 l_t h_w}\left\{1 - \left(\frac{l_w}{l_t}\right)^2\right\} \ (m^2)$$

A_1: As given by the following formulae

Where l_t is not more than 20 m: $0.7 + 0.035 l_t$ (m^2)

Where l_t is more than 20 m: $0.07 l_t$ (m^2)

l_t : As given by the following formula:

$l_w + l_s$ (m)

l_w : Length (m) of the open deck enclosed by bulwarks

l_s : Length (m) of the common space within the open superstructure

b_0 : Breadth (m) of the openings in the end bulkhead of the enclosed superstructure

h_s : One standard superstructure height (m) according to the requirement in **Part V**

h_w: The distance (m) of the well deck above the freeboard deck

(2) The minimum freeing port area on each side of the ship for the open well (A_w) is not to be less than that obtained from the following formula.

$$A_w = \frac{A_2 h_s}{2 h_w} \ (m^2)$$

A_2: As given by the following formulae

Where l_w is not more than 20 m: $0.7 + 0.035 l_w + a$ (m^2)

Where l_w is more than 20 m: $0.07 l_w + a$ (m^2)

a : As obtained from the following formulae

Where h is more than 1.2 m: $0.04 l_w (h - 1.2)$ (m^2)

Where h is not more than 1.2 m, but not less than 0.9 m: 0 (m^2)

Where h is less than 0.9 m: $-0.04 l_w (0.9 - h)$ (m^2)

h : Average height (m) of bulwarks above the deck

l_w, h_s and h_w: As specified in **(1)**

(3) In ships either without sheer or with less sheer than the standard, the minimum freeing port area obtained from **(1)** and **(2)** above is to be multiplied by the factor obtained from the following formula.

$$1.5 - \frac{S}{2S_0}$$

S : Average of actual sheer (mm)

S_0: Average of the standard sheer (mm) according to the requirements in **Part V**

2 The requirements in **21.2.1-4, Part CS** of the Rules apply to type "*A*" or "*B*-100" ships with especially reduced freeboards.

3 The requirements in **21.2.2-4, Part CS** of the Rules apply to type "*A*" or "*B*-100" ships with especially reduced freeboards having trunks.

CS21.2.2 Freeing Port Area

1 A flush-decker having an effective deckhouse is to be considered to have two wells afore and abaft the deckhouse, and each of these wells is required to have a freeing port area as prescribed in **21.2.2, Part CS** of the Rules. The term "effective deckhouse" means a structure having a breadth not less than 80% of the breadth of ship and the width of passageways at its sides does not exceed 1.5 m.

2 Where a divisional bulkhead extending from side to side is provided at the forward end of deckhouse, the ship is to be considered to have two wells afore and abaft the bulkhead, irrespective of the breadth of deckhouse, and each of these wells is required to have the freeing port area prescribed in **21.2.2, Part CS** of the Rules.

3 In ships complying with the provisions of **CS21.2.1-2**, the guardrails installed on more than half the length of the exposed parts of the freeboard deck may be replaced by freeing ports in the lower parts of the bulwarks, for at least 33% of the total area of bulwarks. In ships complying with the provisions of **CS21.2.1-3**, the guardrails installed on half the length of trunks may be replaced by freeing ports in the lower parts of the bulwarks, for at least 33% of the total area of bulwarks.

4 In type "*B*-60" ships, freeing ports in the lower parts of bulwarks are to have an area not less than 25% of the total area of bulwarks.

5 Where freeing ports have rails or other fixtures that reduce the area of the opening, the projected area caused by these fixtures is to be deducted from the actual freeing port area during calculations.

6 Where a recess in the side shell or superstructure of a pure car carrier or similar ship forms a well, adequate freeing ports are to be provided in accordance with the requirements of **21.2.2-3, Part CS** of the Rules.

7

(1) "Where a ship is provided with a trunk or a hatch side coaming which is continuous or substantially continuous between detached superstructures" stipulated in **21.2.2-3, Part CS** of the Rules refers to the case where F_0 is not greater than F_1, and F_0 and F_1 are shown below.

F_0: Free flow area (m^2) through which water runs across the deck given by the following formula

$\sum(l_i h_i - a_i)$

l_i : Distance (m) between hatchways, and between hatchways and superstructures and deckhouses

h_i: Height (m) of bulwarks

a_i: Projected area (m^2) of structures which prevent free flow in $l_i h_i$

F_1: As specified in **21.2.2-1** and **-2, Part CS** of the Rules (m^2)

(2) Where F_0 is greater than F_1, but not greater than F_2, the freeing port area (F) is to be increased by the following formula. F_0 and F_1 are shown in **(1)** above, and F_2 is shown below.

$F = F_1 + F_2 - F_0$ (m^2)

F_2: As specified in **21.2.2-3, Part CS** of the Rules (m^2)

(3) Where F_0 is greater than F_2, F is to be equal to F_1. F_0, F_1 and F_2 are shown in **(1)** and **(2)** above.

CS21.2.3 Arrangement of Freeing Ports

In ships without sheer or having very small sheer, the area of freeing ports is to be distributed throughout the whole length of the well.

CS21.3 Bow Doors and Inner Doors

CS21.3.1 Application

1 "Bow doors" referred to in **21.3.1, Part CS** of the Rules mean the doors provided forward of the collision bulkhead.

2 The "securing device", "supporting device" and "locking device" referred to in **21.3, Part CS** of the Rules mean the following devices.

(1) Securing device: a device used to keep the door closed by preventing it from rotating about its hinges.

(2) Supporting device: a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device that transmits loads from the door to the ship's structure.

(3) Locking device: a device that locks the securing device in the closed position.

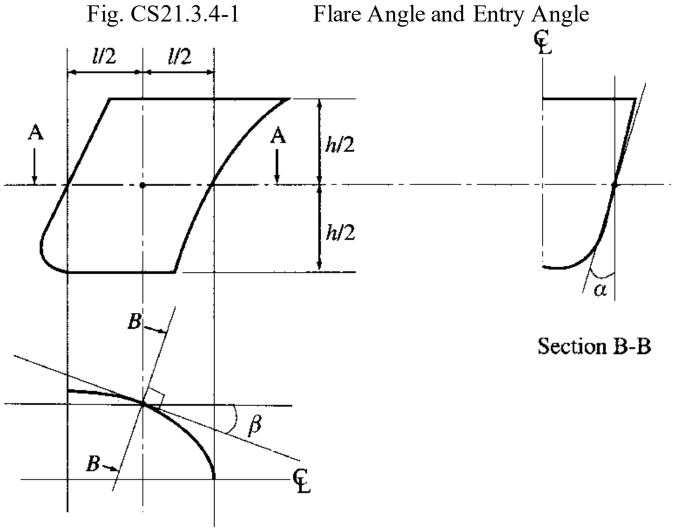
CS21.3.4 Design Loads

The "flare angle" and "entry angle" referred to in **21.3.4, Part CS** of the Rules mean the following angles. (*See*, **Fig. CS21.3.4-1**)

(1) Flare angle at the point to be considered is defined as the angle between a vertical line and the tangent to the side shell plating, measured in a vertical plane normal to the horizontal tangent to the shell plating.

(2) Entry angle at the point to be considered is defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane.

Fig. CS21.3.4-1 Flare Angle and Entry Angle



CS21.3.7 Securing and Supporting of Doors

"All load transmitting elements" referred to in **21.3.7-2(9), Part CS** of the Rules include pins, supporting brackets and back-up brackets.

CS21.3.8 Securing and Locking Arrangement

1 Making opening and closing systems as well as securing and locking devices "interlocked in such a way that they can only operate in the proper sequence" as stipulated in **21.3.8-1(3), Part CS** of the Rules means providing safeguards such as an interlocking system, where the doors can be closed only if securing and locking devices are released.

2 Making operating panels "inaccessible to unauthorized persons" as stipulated in **21.3.8-1(5), Part CS** of the Rules means providing safeguards such as installing a locking device on the operating panel.

3 In the application of **21.3.8-1(6), Part CS** of the Rules, if gravity or friction cannot maintain the door mechanically closed, securing devices such as mechanical pins are to be provided.

4 Indicator lights in the navigation bridge and on local operating panels specified in **21.3.8-2(1), Part CS** of the Rules are to indicate closing and securing conditions for each door. In addition, the required visual alarms are to indicate opening and lock-releasing conditions for each door. A common indicator can be used for both the securing and locking devices.

5 Visual and audible alarms specified in **21.3.8-2(1), Part CS** of the Rules are to be linked with the mode selection switch specified in **21.3.8-2(3), Part CS** of the Rules. The audible alarms may be equipped with a silence function switch.

6 Systems "designed on the fail safe principle" stipulated in **21.3.8-2(2)(a), Part CS** of the Rules means as follows.

(1) The indication panel is provided with:

(a) A power failure alarm

(b) A lamp test

(c) A separate indication for door closed, door locked, door not closed, and door not locked

(2) Limit switches electrically close when the door is closed (when more limit switches are provided they may be connected in series)

(3) Limit switches electrically close when securing arrangements are in place (when more limit switches are provided they may be connected in series)

(4) Two electrical circuits (separate cables even if using multicore cable) with one for the indication of door closed/unclosed and the other for door locked/unlocked

(5) When the limit switches malfunction, an indication to show: unclosed, unlocked, and securing arrangement not in place - as appropriate

7 "A backup power source" referred to in **21.3.8-2(2)(c), Part CS** of the Rules may be regarded as a source of power (e.g., emergency generator with automatic start or electrical batteries) which is capable of supplying power within 45 *seconds* of a failure of the main source of power, or another secure supply of power (e.g., UPS) which is capable of supplying power for 18 *hours*.

8 In order to ensure that the sensors are "protected from water" as specified in **21.3.8-2(2)(d), Part CS** of the Rules, the sensors are required to have at least IP55 enclosures.

9 The "water leakage detection system" referred to in **21.3.8-2(4), Part CS** of the Rules is to be designed on the fail safe principle.

10 The "television surveillance system" referred to in **21.3.8-2(5), Part CS** of the Rules is to be designed on the fail safe principle.

11 The "audible alarm function" referred to in **21.3.8-2(6), Part CS** of the Rules is to be designed on the fail safe principle.

CS21.3.10 Operating and Maintenance Manual

The "Operating and Maintenance Manual" specified in **21.3.10-1 in Part CS** of the Rules is to include the following sentences.

The following recorded inspections of the door supporting and securing devices are to be carried out by the ship's staff;

(1) Inspections at monthly intervals

(2) Inspections following incidents that could result in damage, including heavy weather or contact in the region of doors

CS21.4 Side Shell Doors and Stern Doors

CS21.4.1 Application

1 "Side shell doors" and "stern doors" stipulated in **21.4.1, Part CS** of the Rules refer to the doors provided between the collision bulkhead and the after peak bulkhead and those provided after the after peak bulkhead.

2 The definitions of "securing device", "supporting device" and "locking device" referred to in **21.4, Part CS** of the Rules are to be as specified in **CS21.3.1**.

CS21.4.2 Arrangement of Doors

Shipside doors used for pilot transfer are to be in accordance with Regulation 23.5, Chapter V, SOLAS Convention.

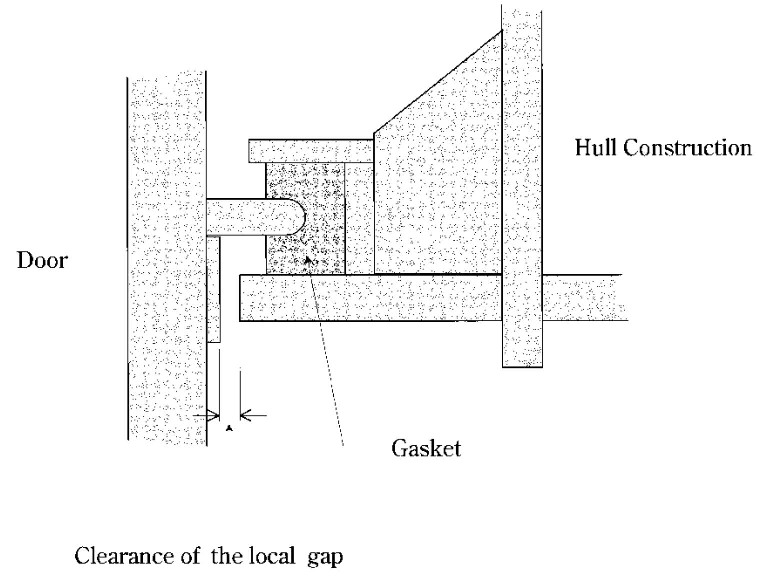
CS21.4.4 Design Loads

Where more than one securing and supporting devices are provided, vertical and horizontal forces may be considered as uniformly distributed between the devices.

CS21.4.6 Securing and Supporting of Doors

The "maximum design clearance between securing and supporting devices" stipulated in **21.4.6-1(4), Part CS** of the Rules refers to the permissible clearance of the local gap of the door in the secured condition. An example is shown in **Fig. CS21.4.6-1**. "All load transmitting elements" referred to in **21.4.6-2(4), Part CS** of the Rules includes pins, supporting brackets and back-up brackets.

Fig. CS21.4.6-1 Maximum Design Clearance between Securing and Supporting Devices



CS21.4.7 Securing and Locking Arrangement

1 Making opening and closing systems as well as securing and locking devices "interlocked in such a way that they can only operate in the proper sequence" as stipulated in **21.4.7-1(3), Part CS** of the Rules means providing safeguards such as an interlocking system, where the doors can be closed only if securing and locking devices are released.

2 Making operating panels "inaccessible to unauthorized persons" as stipulated in **21.4.7-1(5), Part CS** of the Rules means providing safeguards such as installing a locking device on the operating panel.

3 In the application of **21.4.7-1(6), Part CS** of the Rules, if gravity or friction cannot maintain the door mechanically closed, securing devices such as mechanical pin are to be provided.

4 The "Ro-Ro spaces" referred in to **21.4.7-2, Part CS** of the Rules means spaces not normally subdivided in any way and extending to either a substantial length or the entire length of ship in which goods can be loaded and unloaded normally in a horizontal direction. (Refer to **3.2.41, Part R** of the Rules)

5 Indicator lights in the navigation bridge and on local operating panels specified in **21.4.7-2(2), Part CS** of the Rules are to indicate closing and securing conditions for each door. In addition, the required visual alarms are to indicate opening and lock-releasing conditions for each door. A common indicator can be used for both the securing and locking devices.

6 Visual and audible alarms specified in **21.4.7-2(2)(b), Part CS** of the Rules are to be linked with the mode selection switch specified in **21.4.7-2(4), Part CS** of the Rules. The audible alarms may be equipped with a silence function switch.

7 Systems "designed on the fail safe principle" stipulated in **21.4.7-2(3)(a), Part CS** of the Rules means as follows.

(1) The indication panel is provided with:

(a) A power failure alarm

(b) A lamp test

(c) A separate indication for door closed, door locked, door not closed, and door not locked

(2) Limit switches electrically close when the door is closed (when more limit switches are provided they may be connected in series)

(3) Limit switches electrically close when securing arrangements are in place (when more limit switches are provided they may be connected in series)

(4) Two electrical circuits (separate cables even if using multicore cable) with one for the indication of door closed/unclosed and the other for door locked/unlocked

(5) Where the limit switches malfunction, an indication to show: unclosed, unlocked, and securing arrangement not in place - as appropriate

8 "A backup power source" referred to in **21.4.7-2(3)(c), Part CS** of the Rules may be regarded as a source of power, (e.g., emergency generator with automatic start or electrical batteries) which is capable of supplying power within 45 *seconds* of a failure of the main source of power, or another secure supply of power (e.g., UPS) which is capable of supplying power for 18 *hours*.

9 In order to ensure that the sensors are "protected from water" as specified in **21.4.7-2(3)(d), Part CS** of the Rules, the sensors are required to have at least IP55 enclosures.

CS21.4.9 Operating and Maintenance Manual

The "Operating and Maintenance Manual" specified in **21.4.9-1, Part CS** of the Rules is to include the following sentences.

The following recorded inspections of the door supporting and securing devices are to be carried out by the ship's staff;

(1) Inspections at monthly intervals

(2) Inspections following incidents that could result in damage, including heavy weather or contact in the region of doors

CS21.5 Side Scuttles and Rectangular Windows

CS21.5.1 General Application

1 With respect to the provisions of **21.5, Part CS of the Rules**, side scuttles with round or oval openings having areas exceeding 0.16 m^2 are to be treated as windows.

2 With respect to the provisions of **21.5.1-1, Part CS** of the Rules, the design pressures of windows in the fore end bulkheads of superstructures and deckhouses above the third tier located above the freeboard deck and forward of 0.5L are not to be less than the minimum design pressures given in **Table CS21.5, Part CS** of the Rules. However, this requirement may be dispensed with if the height of the highest deck at the fore end is not less than 22 m above the designed maximum load line, or if cargo, etc. is regularly loaded onto exposed decks in front of the windows (e.g., container carriers).

3 With respect to the provisions of **21.5.1-2, Part CS** of the Rules, windows on the navigation bridge up to the third tier above the freeboard deck permitted to be rectangular according to the provisions of **21.5.6, Part CS** of the Rules may be other than those of Class E or Class F subject to the following **(1)** and **(2)**.

(1) The navigation bridge is to be separated from spaces below the freeboard deck and spaces within enclosed superstructures by the followings

(a) Weathertight closing devices

(b) Two or more cabin bulkheads or doors

The height of the doorway sill to the navigation bridge is not to be less than that required for closing devices at the position of such a doorway.

(2) The design pressure of such windows is not to be less than the value specified in **21.5.8, Part CS** of the Rules. The frame of the window is to conform to Class E or Class F according to the location it is installed, and the window is to have appropriate weathertightness.

CS21.5.3 Application of Side Scuttles

The side scuttles "deemed appropriate by the Society" referred to in **21.5.3-5, Part CS** of the Rules are class B side scuttles or class A side scuttles without deadlights in cases where the height of superstructures and deckhouses specified in **21.5.3-5, Part CS of the Rules** is greater than standard quarterdeck height specified in **V2.2.1-1**.

CS21.5.5 Design Pressure and Maximum Allowable Pressure of Side Scuttles

With respect to the provisions of **21.5.5-1, Part CS** of the Rules, the value of coefficient "a" for side scuttles for spaces below the freeboard deck or spaces within superstructures may be determined using the formula for the first tier deckhouse in the provisions of **18.2.1-1, Part CS** of the Rules.

CS21.5.7 Application of Rectangular Windows

The rectangular windows "deemed appropriate by the Society" referred to in **21.5.7-3, Part CS** of the Rules are rectangular windows without shutters or deadlights. In such cases, deckhouses situated on the following spaces may be regarded as being in the second tier of the freeboard deck.

(1) A raised quarterdeck of a height equal to or greater than the standard quarterdeck height specified in **V2.2.1-1**.

(2) The deck of a superstructure of a height equal to or greater than the standard quarterdeck height specified in **V2.2.1-1**.

(3) The deck of a deckhouse of a height equal to or greater than the standard quarterdeck height specified in **V2.2.1-1**

CS21.6 Ventilators

CS21.6.5 Closing Appliances

1 Closing appliances required in **21.6.5, Part CS of the Rules** are to be of steel or other equivalent materials. Furthermore, the closing appliances of the ventilators for machinery and cargo spaces required in **21.6.5-1, Part CS of the Rules** are to have inherent corrosion resistance properties or be provided with an adequate anticorrosion treatment.

2 With respect to the provisions of **21.6.5, Part CS of the Rules**, mechanical ventilation systems are to be provided with warning plates stating that the closing appliances of mechanical ventilation systems are generally to be closed after the ventilation system has been shut off, unless reinforced.

3 With respect to the provisions of **21.6.5-1, Part CS of the Rules**, in cases where internal checks of ventilators are impossible even if equipment installed on board is used, e.g. large ventilators that have cowls which cannot be easily removed or ventilators that have fans installed above, an inspection port at least 150 *mm* in diameter is to be installed in the coaming of the ventilator. In addition, such inspection ports are to be provided with suitable covers so as not to spoil the water tightness/weather tightness and fire resistance required for the coaming of ventilators.

CS21.6.7 Ventilators for Emergency Generator Room

1 Where it is not practicable for the height of ventilator coamings to comply with **21.6.7, Part CS** of the Rules, they are to comply with the following requirements **(1)** or **(2)** instead.

(1) Where the emergency generator room is located in an enclosed superstructure, the ventilators are to have coamings in compliance with **21.6.1, Part CS** of the Rules, and are to be fitted with weathertight closing appliances in combination with other suitable arrangements to ensure adequate ventilation.

(2) In cases other than **(1)** above, where the emergency generator room has no opening leading to a space below the freeboard deck, the height of coamings of ventilators to supply air to the emergency generator room, above the upper surface of the deck, is to be at least 900 *mm* above the surface of the deck in Position I or 760 *mm* above the surface of the deck in Position II specified in **19.1.2, Part CS** of the Rules. In addition, these ventilator openings are to be fitted with suitable protection devices such as louvers to prevent the intrusion of sea-water. Openings on the boundaries of the emergency generator room are to be treated in a similar manner.

2 The weathertight closing appliances and louvers specified in **-1** above are also to comply with requirements specified in **1.3.5-2, Part D of the Rules**.

CS21.6.8 Additional Requirement for Ventilators Fitted on Exposed Fore Deck

The strength of ventilators and their closing devices in **21.6.8, Part CS** of the Rules are to comply with the following requirements.

(1) Applied Loads

Forces acting in the horizontal direction on the pipe and its closing device are to be calculated by using the pressure (p) obtained from the following formula and the largest projected area of each component.

$$p = 0.5\rho V_w^2 C_a C_s C_p \ (kN/m^2)$$

ρ : Density of sea water (1.025 t/m^3)

V_w: Velocity of water over the fore deck given by the following:

$13.5 (m/sec)$: for $h_{ed} \leq 0.5 h_t$

$13.5\sqrt{2\left(1-\frac{h_{ed}}{h_t}\right)} (m/sec)$: for $0.5h_t < h_{ed} < h_t$

h_{ed}: Distance from the designed maximum load line to exposed deck (m)

h_t : $0.1L_1$ or 22 m whichever is the lesser

C_d: Shape coefficient (0.5 for pipes and 1.3 for ventilator head in general, 0.8 for ventilator head of cylindrical form with its axis in the vertical direction)

C_s: Slamming coefficient (3.2)

C_p: Protection coefficient given by the following

(0.7): for pipes and ventilator heads located immediately behind a breakwater or forecastle

(1.0): elsewhere and immediately behind a bulwark

(2) Strength Requirements

(a) Bending moments and stresses in air and ventilator pipes are to be calculated at critical positions, such as at penetration pieces, at weld or flange connections, and at toes of supporting brackets. Bending stresses in the net section are not to exceed 0.8 times σ_y, where σ_y is the specified minimum yield stress or 0.2% proof stress of steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 *mm* is then to be applied.

(b) For standard ventilators of 900 *mm* height closed by heads of not more than the tabulated projected area, pipe thickness standards are to be according to **Table CS21.6.8-1.** Where brackets are required, three or more radial brackets of a gross thickness of 8 *mm* or more, of a minimum length of 100 *mm*, and a height according to **Table CS21.6.8-1** are to be fitted; but they need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.

(c) For other configurations, loads according to **(1)** are to be applied, and means of support are to be determined in order to comply with the requirements of **(a)**. Brackets, where fitted, are to be of suitable thickness and length according to their height. Pipe thickness is not to be less than as indicated in column 1of **Table CS21.7, Part CS** of the Rules.

(d) All component parts and connections of the air pipe or ventilator are to be capable of withstanding the loads defined in **(1)**.

(e) Rotating type mushroom ventilator heads are deemed unsuitable.

Table CS21.6.8-1 900 *mm* Ventilator Pipe Thickness and Bracket Standards

Nominal pipe diameter (*mm*)	Minimum fitted gross thickness (*mm*)	Maximum projected area of head (cm^2)	Height of brackets (*mm*)
80*A*	6.3	-	460
100*A*	7.0	-	380
150*A*	8.5	-	300
200*A*		550	-
250*A*		880	-
300*A*		1200	-
350*A*		2000	-
400*A*		2700	-
450*A*		3300	-
500*A*		4000	-

CS21.7 Gangways

CS21.7.1 General

1 In order to satisfy the provisions of **21.7.1, Part CS** of the Rules that require a means of protecting crew passageways on the exposed freeboard or raised quarterdeck, a means from **Table CS21.7.1-1** is to be provided according to the assigned freeboard or location onboard

2 In **Table CS21.7.1-1**, "**a**" to "**f**" refer to installations and **1)** to **5)** refer to locations onboard, as specified in the following **(1)** and **(2)**.

(1) Acceptable arrangements

a: A well lighted and ventilated under-deck passageway (clear opening 0.8 *m* wide, 2.0 *m* high) as close as practicable to the freeboard deck, connecting and providing access to the locations in question

b: A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship, providing a continuous platform at least 0.6*m* in width and a non-slip surface, with guard rails extending on each side throughout its length

Guard rails shall be at least 1 *m* high with courses as required in **21.1.2-2, Part CS** of the Rules, and supported by stanchions spaced not more than 1.5 *m*, and with a foot-stop.

c: A permanent walkway at least 0.6 *m* in width fitted at freeboard deck level consisting of two rows of guard rails with stanchions spaced not more than 3 *m* apart

The number of courses of rails and their spacing are to be as required by **21.1.2-2, Part CS** of the Rules. On Type B ships, hatch coamings not less than 0.6 *m* in height may be regarded as forming one side of the walkway, provided that between the hatches two rows of guard rails are fitted.

d: A 10 *mm* minimum diameter wire rope lifeline supported by stanchions not more than 10 *m* apart, or a single hand rail or wire rope attached to hatch coamings, continued and adequately supported between hatches

e: A permanent and efficiently constructed gangway for tankers fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship:

- located so as not to hinder easy access across the working areas of the deck
- providing a continuous platform at least 1.0 *m* in width
- constructed of fire resistant and non-slip material
- fitted with guard rails extending on each side throughout its length; guard rails should be at least 1.0 *m* high with courses as required by **21.1.2-2, Part CS** of the Rules, and supported by stanchions spaced not more than 1.5 *m*
- provided with a foot stop on each side
- having openings (not more than 40 *m* apart) with ladders where appropriate, to and from the deck
- having shelters of substantial construction set in way of the gangway at intervals not exceeding 45 *m* if the length of the exposed deck to be traversed exceeds 70 *m*

  Every such shelter should be capable of accommodating at least one person ($1 \times 1 \times 2$ *m* in size as standard, and at least 0.6 *m* in width of entrance), be so constructed as to afford weather protection on the forward, port and starboard sides and the strength is to be in accordance with the requirements of **Chapter 18, Part CS** of the Rules.

f: A permanent and efficiently constructed walkway fitted at or above the level of the freeboard deck on or as near as practicable to the centre line of the ship having the same specifications as those for a permanent gangway listed in the arrangements "**e**" except for footstops

On type B ships (certified for the carriage of liquids in bulk), with a combined height of hatch coamings and fitted hatch covers of together not less than 1 *m* in height, the hatch coamings may be regarded as forming one side of the walkway, provided that between the hatches two rows of guard rails are fitted.

(2) Alternative transverse locations for arrangements

1): At or near the centre line of the ship; or fitted on hatch covers at or near the centre line of the ship

2): Fitted on each side of the ship

3): Fitted on one side of the ship, provision being made for fitting on either side

4): Fitted on one side only

5): Fitted on each side of the hatches as near to the centre line as practicable

3 Precautions regarding arrangements specified in **-1** above

(1) Where wire ropes are fitted, turnbuckles are to be provided to ensure their tautness.

(2) Wire ropes may only be acceptable in lieu of guard rails in special circumstances and then only in limited lengths.

(3) Lengths of chain may only be acceptable in lieu of guard rails where fitted in between two fixed stanchions.

(4) Where stanchions are fitted, every third stanchion is to be supported by a bracket or stay.

(5) Removable or hinged stanchions shall be capable of being locked in the upright position.

(6) A means of passage over obstructions, if any, such as pipes or other fittings of a permanent nature, should be provided.

(7) Generally, the width of the gangway and deck-level walkway should not exceed 1.5 *m*.

4 Where a suitable passage facility is unable to be secured on or under the deck due to cargoes loaded on the exposed deck, life lines or guardrails are to be provided on the cargo on or near the centre line of the ship. Where a lumber freeboard is assigned, in addition to the above, life lines or guardrails, the height of which is at least 1.0 *m* and the clearance between courses is less than 350 *mm*, are to be fitted on both sides of the deck lumber.

Table CS21.7.1-1 Protection of Crew on Exposed Deck or Raised Quarter Deck

Locations of access in Ship	Assigned Summer Freeboard	Acceptable arrangements according to type of freeboard assigned:			
		Type A	Type B-100	Type B-60	Type B&B+
1.1 Access to Midship Quarters 1.1.1 Between poop and bridge,	≤ 3000 mm	A b e	a b e	a b c 1) e f 1)	a b c 1) c 2) c 4) d 1) d 2) d 3) e f 1) f 2) f 4)
1.1.2 Between poop and deckhouse containing living quarters or navigating equipment, or both.	> 3000 mm	A b e	a b e	a b c 1) c 2) e f 1) f 2)	
1.2 Access to Ends 1.2.1 Between poop and bow (if there is no bridge) 1.2.2 Between bridge and bow. 1.2.3 Between a deckhouse containing living quarters	≤ 3000 mm	A b c 1) e f 1)	a b c 1) c 2) e f 1) f 2)	a b c 1) c 2) e f 1) f 2)	
or navigating equipment, or both, and bow 1.2.4 In the case of a flush deck vessel, between crew accommodation and the forward and after ends of ship	> 3000 mm	a b c 1) d 1) e f 1)	a b c 1) c 2) d 1) d 2) e f 1) f 2)	a b c 1) c 2) c 4) d 1) d 2) d 3) e f 1) f 2) f 4)	

CS21.7.2 Tankers

1 Notwithstanding **CS21.7.1**, safe access to the bow is to be provided by at least one permanent arrangement noted in **Table CS21.7.2-1**.

2 Notations in **Table CS21.7.2-1** are as specified in **CS21.7.1-2**.

3 For tankers less than 100 m in length, the minimum width of the gangway platform or deck level walkway fitted in accordance with the arrangements "**e**" or "**f**", respectively, may be reduced to 0.6 m.

4 For gas carriers, where gangways are provided sufficiently high above the freeboard deck or where permanently constructed arrangements achieve an equivalent level of safety, the Society may approve modifications to the provisions of **-1** above. "Sufficiently high above the freeboard deck" means a vertical height of more than 3 times the standard superstructure height specified in **Table V2.2.1-1**.

Table CS21.7.2-1 Protection of Crew on Exposed Freeboard Deck or Raised Quarter Deck for Tankers

<table>
<tr><th>Location of access in Ship</th><th>Assigned Summer Freeboard</th><th>Acceptable arrangements according to type of freeboard assigned:</th></tr>
<tr><td rowspan="2">2.1 Access to Bow
2.1.1 Between poop and bow
2.1.2 Between a deckhouse containing living accommodation or navigating equipment or both, and bow
2.1.3 In the case of a flush deck vessel, between crew accommodation and the forward ends of ship</td><td>$\leq (Af + Hs)^*$</td><td>a
e
f 1)
f 5)</td></tr>
<tr><td>$> (Af + Hs)^*$</td><td>a
e
f 1)
f 2)</td></tr>
<tr><td>2.2 Access to After End
2.2.1 In the case of a flush deck vessel, between crew accommodation and the after end of ship</td><td colspan="2">As required in 1.2.4 of Table CS21.7.1-1 for other types of ships</td></tr>
</table>

Notes:

Af: Minimum summer freeboard calculated as type A ship regardless of the type of freeboard actually assigned

Hs: Standard height of superstructure as defined in **Table V2.2.1-1, Part V of the Guidance.**

CS21.8 Means of Embarkation and Disembarkation

CS21.8.1 General

1 The wording "specially approved by the Society" specified in **21.8.1, Part CS of the Rules** means those cases where a ship is engaged in voyages between designated ports where appropriate shore accommodation/embarkation ladders (platforms) are provided.

2 With respect to the requirements specified in **21.8.1, Part CS of the Rules**, the means of embarkation and disembarkation are to be in accordance with the following. However, ships that have small freeboards and are provided with boarding ramps needs not to be in accordance with the following:

(1) Accommodation ladders and gangways are to be constructed based on ISO 5488:1979 "*Shipbuilding - accommodation ladders*", ISO 7061:1993 "*Shipbuilding - aluminium shore gangways for seagoing vessels*" or standards where deemed appropriate by the Society. Accommodation ladder winches are to be constructed based on ISO 7364:1983 "*Shipbuilding and marine structures – deck machinery – accommodation ladder winches*" or standards where deemed appropriate by the Society or are to be the one pursuant to aforementioned standards.

(2) The structure of the accommodation ladders and gangways and their fittings and attachments are to be such as to allow regular inspection, maintenance of all parts and, if necessary, lubrication of their pivot pin. Special care is to be paid to welding connection.

(3) As far as practicable, the means of embarkation and disembarkation are to be sited clear of the working area and are not to be placed where cargo or other suspended loads may pass overhead. However, in cases where the Society recognizes unavoidable circumstances, the means of embarkation and disembarkation may be installed within the above mentioned areas or places, provided that safe passage is ensured through description in operation manuals, the installation of warning plates, and so on.

(4) Each accommodation ladder is to be of such a length to ensure that, at a maximum design operating angle of inclination, the lowest platform will be not more than 600 *mm* above the waterline in the lightest seagoing condition (in this regard, trim is to be the condition resulting from the loading condition of the lightest seagoing condition), as defined in SOLAS Regulation III/3.13. However, in cases where the height of the embarkation/disembarkation deck exceeds 20 *m* above the waterline or is deemed appropriate by the Society, an alternative means of providing safe access to the ship or supplementary means of access to the bottom platform of the accommodation ladder may be accepted.

(5) The arrangement at the head of the accommodation ladder is to provide direct access between the ladder and the ship's deck by a platform securely guarded by handrails and handholds. The ladder is to be securely attached to the ship to prevent overturning.

(6) Each accommodation ladder or gangway is to be clearly marked at each end with a plate showing the restrictions on the safe operation and loading, including the maximum and minimum permitted design angles of inclination, design load, maximum load on bottom end plate, etc. Where the maximum operational load is less than the design load, it is also to be shown on the marking plate.

(7) Gangways are not to be used at an angle of inclination greater than 30 *degrees* from the horizontal and accommodation ladders are not to be used at an angle greater than 55 *degrees* from the horizontal, unless designed and constructed for use at angles greater than these and marked as such.

(8) Gangways are not to be secured to a ship's guardrails unless they have been designed for that purpose. If positioned through an open section of bulwark or railings, any remaining gaps are to be adequately fenced.

(9) Adequate lighting is to be provided to illuminate the means of embarkation and disembarkation, the position on deck where persons embark or disembark and the controls of the arrangement.

(10) A lifebuoy equipped with a self-igniting light and a buoyant lifeline is to be available for immediate use in the vicinity of the embarkation and disembarkation arrangement when in use. This lifebuoy is not to be taken into account when determining the minimum number and distribution of lifebuoys as required by *SOLAS* Reg. III/32.1.1.

(11) A safety net is to be mounted and arrangements that enable the installation of such net are to be provided to prevent falling accident in cases where it is possible that a person may fall from the means of embarkation and disembarkation or between the ship and quayside.

CS22 CEILINGS, SPARRINGS, CEMENTING AND PAINTING

CS22.2 Sparrings

CS22.2.1 Sparrings

1 The “equivalent arrangements … for the protection of framing” prescribed in **22.2.1-1, Part CS** of the Rules are to be in accordance with the following **(1)** and **(2)**.

(1) Hold frames are to be stiffened by one of the following:

(a) Longitudinal stiffeners or tripping brackets are to be fitted at intervals of about 2 m.

(b) Angle bars are to be fitted longitudinally at intervals of about 1.5 m on the flange surface of hold frames.

(c) Flat bars of about 150 mm wide 10 mm thick are to be fitted longitudinally at intervals of about 0.5 m on the flange surface of hold frames.

(2) Angle bars or flat bars (in case of flat bars, at least 2 tiers) are to be fitted longitudinally on the flange surface of tank side brackets or on the lower bracket of hold frames of bulk carrier type ships. However, the above requirements may be dispensed with where the thickness and breadth of the flange of hold frames of bulk carrier type ships are not less than that determined by the following.

(a) Thickness of bracket t = As determined by **Table CS1.4 of Part CS of the Rules** taking the arm length in **Fig. CS22.2.1-1** as the longer arm of the bracket

(b) Breadth of flange b = Value obtained from the following formula

$128\sqrt{d_0 l}$ (mm)

d_0: Depth of throat of bracket (m)

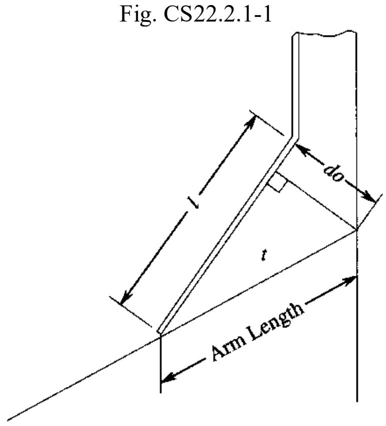
l: Length of flange of bracket (m)

2 For ships intended to carry timbers, the special protection of framing is to be in accordance with the following **(1)** and **(2)** in addition to the requirements of **-1** above,

(1) Where hold frames come right under hatchway at forward or after part of ship, the hold frames are to be stiffened further.

(2) Consideration is to be given on arrangement and size of tripping brackets for deep hold frames or other similar deep hull structural members.

Fig. CS22.2.1-1



CS22.4 Painting

CS22.4.1 General

1 Limitation of Using Aluminium Paint

Paints containing aluminium greater than 10 percent aluminium by weight in the dry film are not to be used in hazardous areas defined in **4.2.3-1** or **4.2.3-2, Part H** of the Rules in tankers and ships carrying dangerous chemicals in bulk intended to carry crude oil and petroleum products having a flashpoint not exceeding 60℃ and a Reid vapour pressure below atmospheric pressure or other liquid cargoes having similar fire hazards.

2 Cathodic Protection System

With respect to the provisions of **22.4, Part CS** of the Rules, where a cathodic protection system is adopted as a backup for coating or the omission of painting, the cargo tanks and their adjacent tanks in tankers and ships carrying dangerous chemicals in bulk, intended to carry crude oil and petroleum products having a flash point not exceeding 60°C and Reid vapour pressure below atmospheric pressure or other liquid cargoes having similar fire hazards are to be in accordance with the following requirements.

(1) 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 the anode does not come free when the surroundings become wasted.

(2) The anode is to be provided in accordance with **(a)** or **(b)**. When anode inserts and/or supports are welded to the structure, they are to be arranged so that the welds are clear of stress raisers. The supports at each end of an anode are not to be attached to separate structures which are likely to move independently.

(a) The steel inserts are to be attached to the structure by means of a continuous weld of adequate section.

(b) The steel inserts are to be attached to separate supports which are attached to the structure by means of a continuous weld of adequate section, by bolting, provided a minimum two bolts with locknuts are used or by appropriate mechanical means of clamping deemed as equivalent by the Society.

(3) Where anodes of aluminium or aluminium alloy are used, they are to meet the following requirements.

(a) Anodes are to be located such that their potential energy does not exceed 274.68*N-m*. The height of the anode is to be measured from the bottom of the tank to the centre 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 anodes are located on horizontal surfaces not less than 1*m* wide and 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.

(b) Anodes are not to be located under tank hatches or butterworth openings, unless protected from any objects falling on the fitted anodes by an adjacent structure.

(4) Anodes of magnesium or magnesium alloy are not permitted.

CS22.4.2 Protective Coatings in Dedicated Seawater Ballast Tanks and Double-side Skin Spaces

1 The application of **22.4.2**, **Part CS** of the Rules with respect to coating system applications is to be in accordance with IACS Unified Interpretations SC223, as may be amended.

2 With respect to the provision of **22.4.2, Part CS of the Rules,** the following tanks are not considered to be dedicated seawater ballast tanks, provided the coatings applied in the tanks described in **(2)** below are confirmed by the coating manufacturer to be resistant to the media stored in the tanks, and are applied and maintained according to the coating manufacturer's procedures.

(1) Tanks identified as "Spaces included in Net Tonnage" in the International Convention on Tonnage Measurement of Ships, 1969

(2) Sea water ballast tanks in livestock carriers also designated for the carriage of the livestock dung

CS22.4.3 Corrosion Protection for Cargo Oil Tanks

1 "Crude oil tankers" in **22.4.3, Part CS of the Rules** refers to ships defined in **2.1.1(19), Part 1 of the Rules for Marine Pollution Prevention Systems**, and falling under items 1.11.1 or 1.11.4 of the Supplement to the International Oil Pollution Prevention Certificate (Form B).

2 The requirements of **22.4.3, Part CS of the Rules** need not be applied to "combination carrier" defined in **2.1.1(8), Part 1 of the Rules for Marine Pollution Prevention Systems** and "ships carrying dangerous chemicals in bulk" including ships certified to carry oil stipulated in **2.1.1(1), Part 1 of the Rules for Marine Pollution Prevention Systems**.

3 With respect to **22.4.3(1), Part CS of the Rules**, IACS Unified Interpretation SC259 as may be amended is to be applied.

4 With respect to **22.4.3(2), Part CS of the Rules**, IACS Unified Interpretation SC258 as may be amended is to be applied.

CS23 EQUIPMENT

CS23.1 Anchors, Chain and Ropes

CS23.1.1 General

1 The "special consideration" referred to in **23.1.1-3, Part CS of the Rules** means the evaluation of the design effectiveness of anchors, chain cables and windlasses.

CS23.1.2 Equipment Numbers

1 Significant figures are to be taken as follows:

(1) Dimensions, such as length, height, and breadth are to be in metres rounded to two decimal places.

(2) The displacement W is to be measured in tons in whole numbers.

(3) Terms in the formula ($W^{2/3}$, $2.0(hB+S_{fun}$, $0.1A$) are to be rounded to the nearest whole number.

Example

$L_2 = 313.00\ m$ (Designed)

$_2 = 313.06\ m$ (Scantling)

$B = 48.20\ m$

$D = 25.50\ m$

$d = 19.00\ m$ (Designed)

$d_s = 19.8\ m$ (Scantling)

$W = 253{,}800\ t$ (Scantling)

$f = 25.50 - 19.80 = 5.70$

$h' = 2.70 \times 4 + 2.80 \times 1 = 13.60$

$h = 5.70 + 13.60 = 19.30$

$f \times {}_2 = 5.70 \times 313.06 = 1{,}784.4$

(figures below 1st place of decimals omitted)

$(h'' \times l)$

Upper deck house $= 2.70 \times 40.85 = 110.2$

(figures below 1st place of decimal omitted)

A deckhouse $= 2.70 \times 40.85 = 110.2$ (〃)

B deckhouse $= 2.70 \times 34.85 = 94.0$ (〃)

+) C deckhouse $= 2.70 \times 34.85 = 94.0$ (〃)

$\sum(h'' \times l) = 408.4$

$A = 1{,}784.4 + 408.4 = 2{,}192$ (fraction omitted)

$W^{2/3} = 253{,}800^{2/3} = 4{,}009$

(whole number rounded to nearest)

$2.0\,hB = 2.0 \times 19.30 \times 48.20 = 1{,}861$ (〃)

+) $0.1\,A = 0.1 \times 2{,}192 = 219$ (〃)

Equipment number $= 6{,}089$

2 Measurement of breadth of structures for second term of the formula in **23.1.2, Part CS of the Rules**

(1) Structures are to be treated as separated above and below by a deck level. A continuous superstructure or deckhouse situated on one tier is to be treated as a single structure irrespective of the mode of variation of their breadth and height, continuous or discontinuous, and the breadth is to be the largest one as shown in **Fig. CS23.1.2-1**.

(2) As for detached independent deckhouses on one tier, breadths of respective deckhouses are to be measured separately to determine whether they are to be included or not. (*See* **Fig. CS23.1.2-2**)

(3) Where a deckhouse having a breadth greater than $B/4$ is above a deckhouse with a breadth of $B/4$ or less, the narrow deckhouse may be ignored. (*See* **Fig. CS23.1.2-3**)

(4) When calculating h, sheer and trim are to be ignored. (*See* **Fig. CS23.1.2-4**)

3 Side projected area A may be in accordance with following **(1)** and **(2)**.

(1) The area of deck camber may disregarded when determining side projected area A.

(2) Side projected area A may be calculated using following formula.

(a) A is the value obtained from the following formula:

$aL_2 + \sum h''l$

$\Sigma h''l$: Sum of the products of the height h'' (m) and length l (m) of superstructures, deckhouses, trunks or funnels which are located above the uppermost continuous deck within L_2 and also have a breadth greater than $B/4$ and a height greater than 1.5 m

(b) Structures are to be treated as separated above and below by a deck level. A continuous superstructure or deckhouse situated on one tier is to be treated as a single structure irrespective of the mode of variation of their breadth and height, continuous or discontinuous. The length of the single structure is to be the value at the largest point. However, if the height is not more than 1.5 m, the part of the single structure is to be ignored. (See **Fig. CS23.1.2-5**)

(c) h'' is the height (m) at the centreline of each tier of deckhouses having a breadth greater than $B/4$.

4 Structures to be included in the third term of the formula in **23.1.2, Part CS of the Rules**

(1) The following items may be excluded from ship side projected area A:

(a) portions outside the fore and aft ends of L

(b) derrick posts, ventilators, etc. in continuation with superstructures or deckhouses

(c) cargoes loaded on decks

Fig. CS23.1.2-1

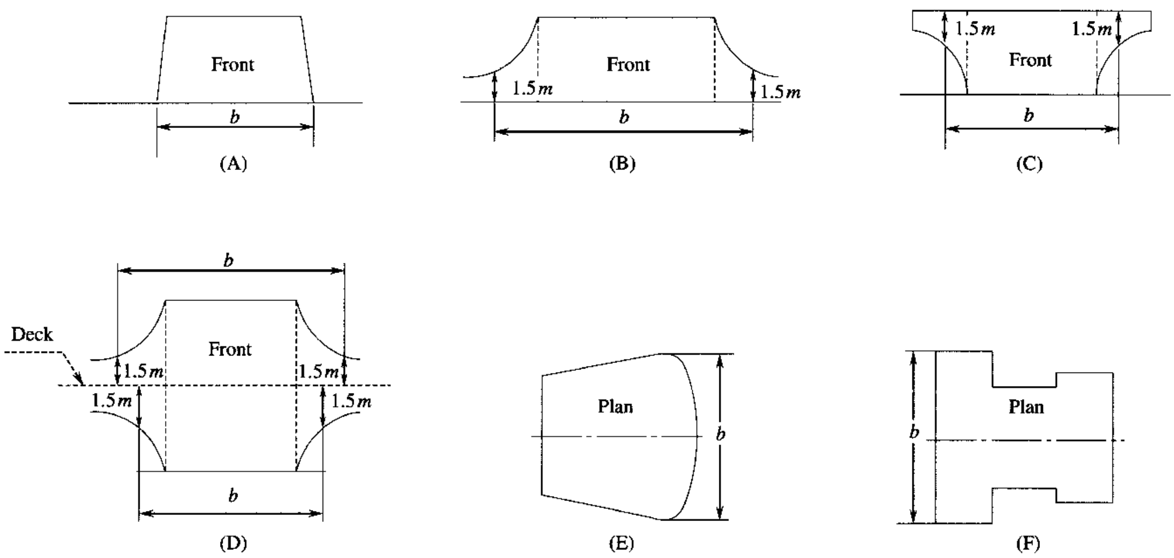
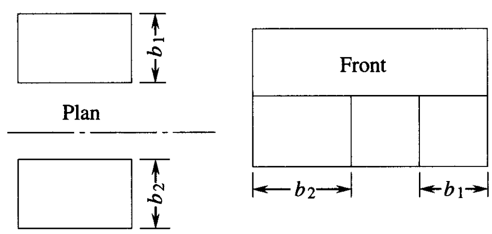


Fig. CS23.1.2-2



Note:

If both b_1 and b_2 are less than $B/4$, they are not to be included (irrespective of the sum b_1+b_2)

Fig. CS23.1.2-3

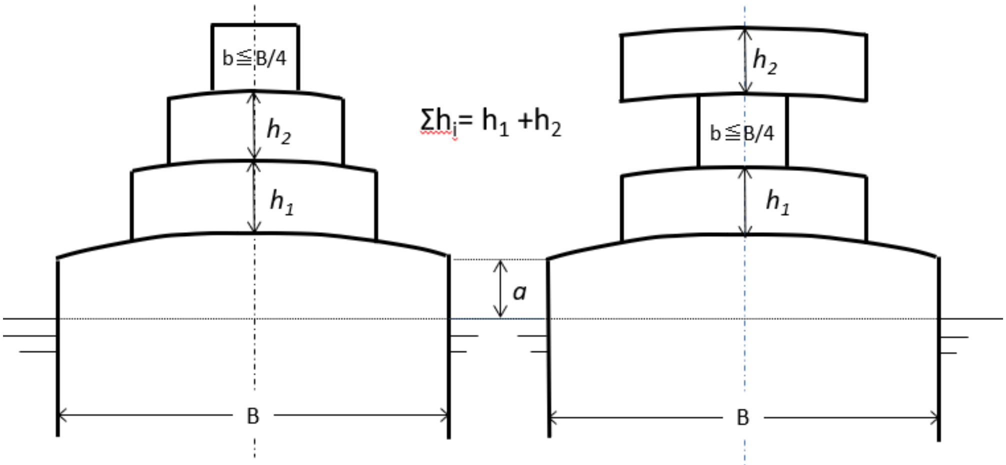


Fig. CS23.1.2-4

$$\sum h' = h_1 + h_2 + h_3$$

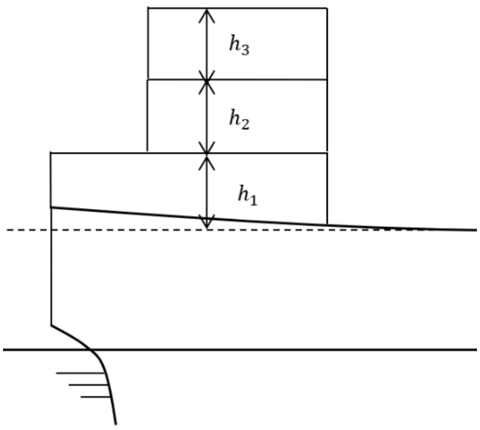
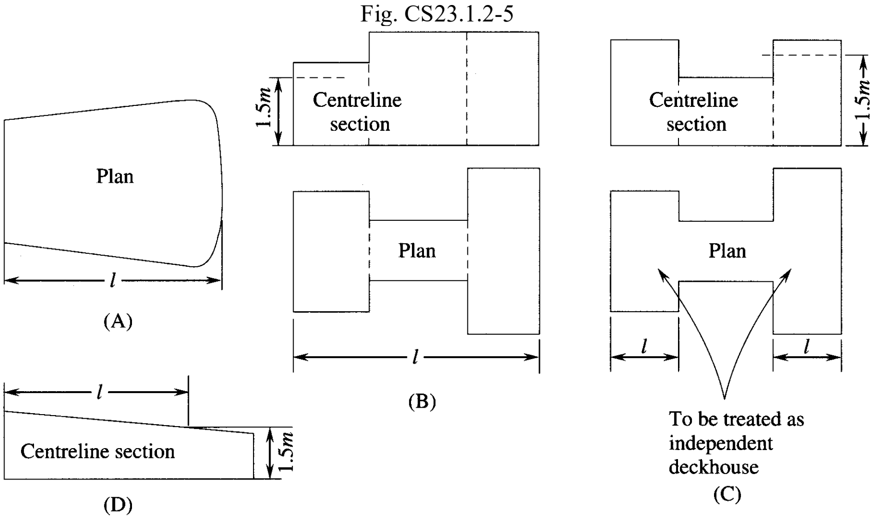


Fig. CS23.1.2-5



CS23.1.4 Chain Cables

Wire ropes may be used in place of chain cables on ships that do not intend to use their anchor in normal temporary anchoring operations or that uses anchoring equipment for positioning with a minimum of 4 points (e.g. for cable or pipe laying) as the following **(1)** to **(5)** are satisfied.

(1) The length of the wire rope is to be equal to 1.5 *times* the corresponding length of chain cable specified in **Table CS23.1, Part CS of the Rules** and its strength is to be equal to that of a Grade 1 chain cable as specified in **Table L3.5, Part L of the Rules**.

(2) The anchor weight shall be increased by 25 % compared to anchor associated with chain cable according to **Table CS23.1, Part CS of the Rule**.

(3) A short length of chain cable is to be fitted between the wire rope and anchor having a length of 12.5 *m* or the distance between anchor in its stowed position and the winch, whichever is less.

(4) All surfaces coming into contact with the wire rope need to be rounded with a radius of not less than 10 *times* the wire rope diameter (including the stem).

(5) Steel wire shall be selected to fit for purpose based on the manufacturer recommendation and shall be provided with guidance for maintenance and inspection.

CS23.1.5 Chain Lockers

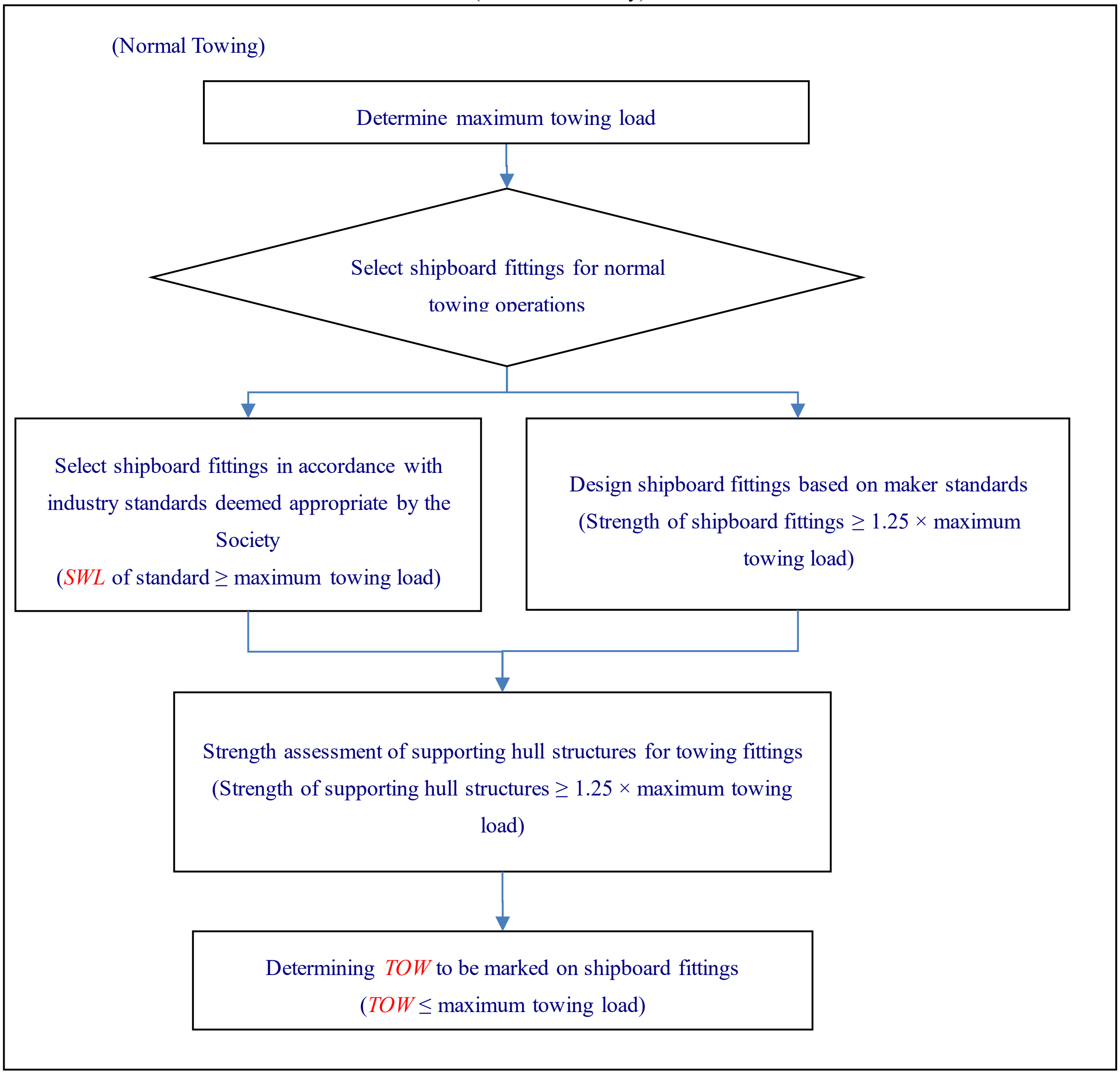
The wording “the access cover and its securing arrangements to the satisfaction of the Society” in **23.1.5-5, Part CS of the Rules** means those which are in accordance with *JIS* F 2304, *JIS* F 2329, or *ISO* 5894:1999 or their equivalent.

CS23.2 Towing and Mooring Fittings

CS23.2.1 General

With respect to the provisions of **23.2, Part CS of the Rules**, the flow charts shown in **Fig. CS23.2.1-1** and **Fig. CS23.2.1-2** are standard methods for the design processes of tow lines, mooring lines, shipboard fittings and their supporting hull structures.

Fig. CS23.2.1-1 Standard Design and Selection Process for Tow Lines, Towing Arrangements and Supporting Hull Structures (for reference only)



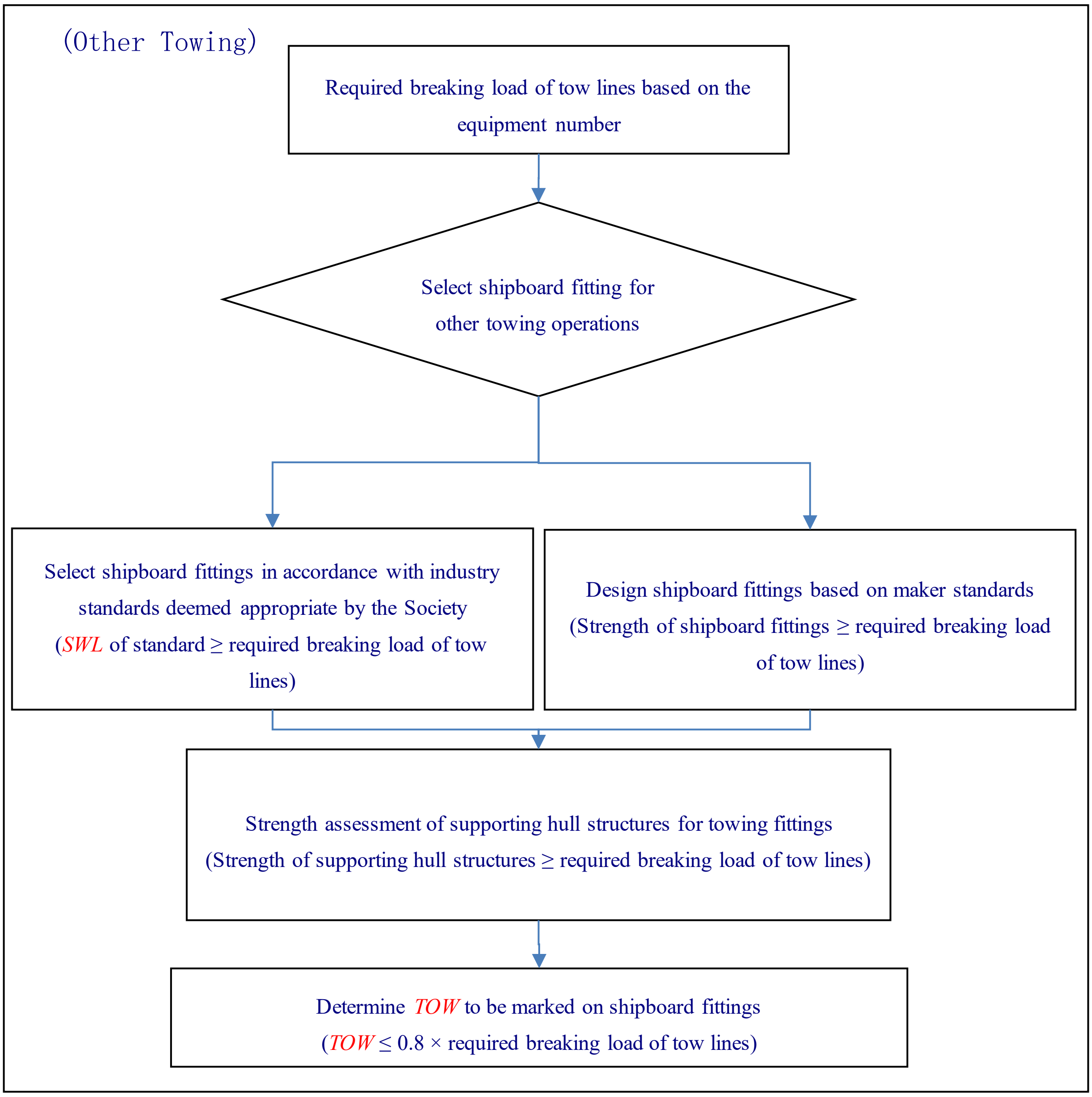
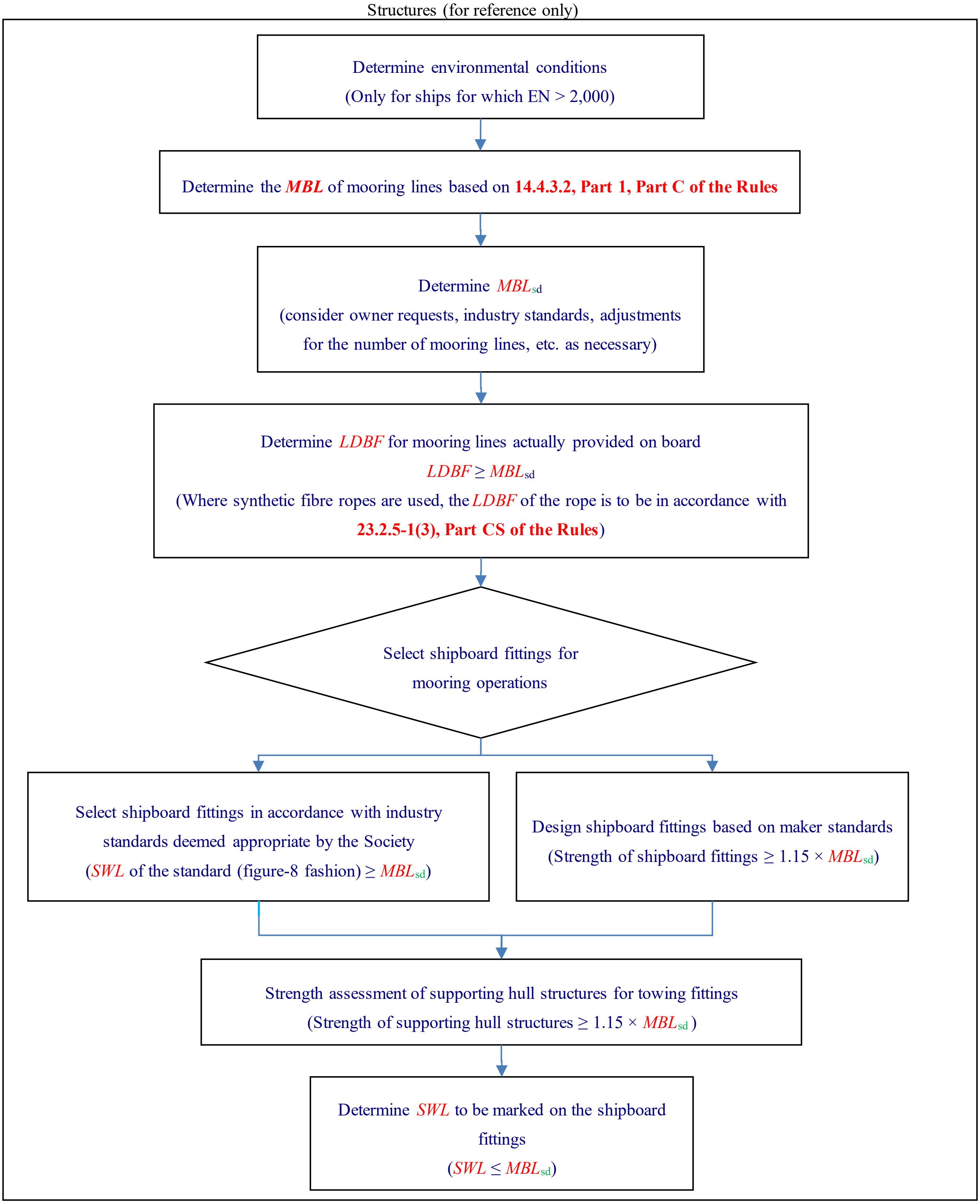

(Other Towing)
Required breaking load of tow lines based on the equipment number
Select shipboard fitting for other towing operations
Select shipboard fittings in accordance with industry standards deemed appropriate by the Society (SWL of standard ≥ required breaking load of tow lines)
Design shipboard fittings based on maker standards (Strength of shipboard fittings ≥ required breaking load of tow lines)
Strength assessment of supporting hull structures for towing fittings (Strength of supporting hull structures ≥ required breaking load of tow lines)
Determine TOW to be marked on shipboard fittings (TOW ≤ 0.8 × required breaking load of tow lines)

Fig. CS23.2.1-2 Standard Design and Selection Process for Mooring Lines, Mooring Arrangements and Supporting Hull Structures (for reference only)



CS23.2.3 Towing Fittings

1 "Industry standards deemed appropriate by the Society" as prescribed in **23.2.3-3(1), Part CS of the Rules**, means international standards or national standards such as *ISO*, *JIS F*, etc.

2 The provisions for the *TOW* specified in **23.2.3-6, Part CS of the Rules** are applied for the use of no more than one line. If not otherwise specified the *TOW* for towing bitts (double bollards) is the load limit for tow lines attached with eye splices.

3 Towing arrangements are recommended as follows.

(1) Tow lines are to be led through a closed chock. The use of open fairleads with rollers or closed roller fairleads is to be avoided.

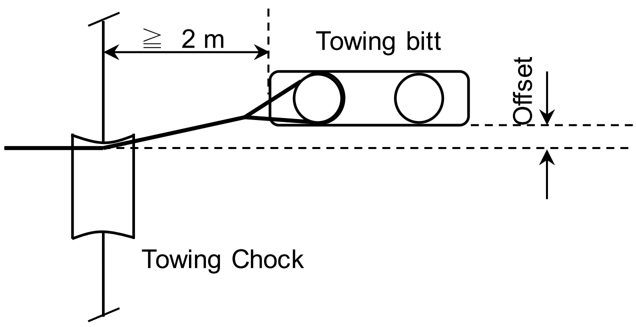
(2) It is recommended to provide at least one chock close to centreline of the ship forward and aft. It is beneficial to provide additional chocks on the port and starboard sides at the transom and at the bow.

(3) Tow lines are to have a straight lead from the towing bitt or bollard to the chock. Bitts or bollards serving chocks are to be located slightly offset and at a distance of at least 2 *m* away from the chock. (See **Fig. CS23.2.3-1**)

(4) Warping drums are to be positioned not more than 20 *m* away from chocks measured along the path of the line as far as practicable.

(5) Attention is to be given to the arrangement of the equipment for towing and mooring operations in order to prevent interference of mooring and tow lines as far as practicable.

Fig. CS23.2.3-1 Sample Arrangement of Towing Fittings



CS23.2.6 Mooring Fittings

1 The requirements in **23.2, Part CS of the Rules** also apply to additional mooring fittings as well as their supporting hull structures. However, MBL_{sd} specified in **23.2.6-3(1), Part CS of the Rules** and MBL_{sd} specified in **23.2.6-4, Part CS of the Rules** may be read as assumed values in consideration of the intended use. This information is to be incorporated into the towing and mooring arrangement plan specified in **23.2.9, Part CS of the Rules.**

2 The "industry standards deemed appropriate by the Society" referred to in **23.2.6-3(1), Part CS of the Rules** means international standards or national standards such as *ISO*, *JIS F*, etc.

3 The provisions for *SWL* specified in **23.2.6-6, Part CS of the Rules** apply only in cases where no more than one line is used.

4 Mooring arrangements are recommended to be as follows.

(1) As far as possible, a sufficient number of mooring winches is to be fitted to allow for all mooring lines to be belayed on winches. If the mooring arrangement is designed such that mooring lines are partly belayed on bitts or bollards, it is to be considered that these lines may not be as effective as the mooring lines belayed on winches. Mooring lines are to have as straight a lead as is practicable from the mooring drum to the fairlead.

(2) At points of changes in direction, sufficiently large radii of the contact surface of a rope on a fitting is to be provided to minimize the wear experienced by mooring lines and as recommended by the rope manufacturer for the rope type intended to be used.

(3) Attention is to be given to the arrangement of the equipment for mooring operations in order to prevent interference of the mooring lines as far as practicable.

CS23.2.9 Towing and Mooring Arrangements Plan

1 It is recommended that the information related to safe towing and mooring operation in the towing and mooring arrangement plan specified in **23.2.9, Part CS of the Rules** is incorporated into the pilot card in order to provide pilots with relevant information on harbour or escort operations.

2 With respect to the provisions specified in **23.2.9-2(6), Part CS of the Rules**, the design condition related to **23.2.5-3(2), Part CS of the Rules** is to be described in this plan as a note.

CS23.2.10 Inspection and Maintenance of Mooring Equipment Including Mooring Lines

The wording "deemed appropriate by the Society" in **23.2.10, Part CS of the Rules** means those which are in accordance with **B2.1.6-10, Part B of the Guidance**.

CS24 TANKERS

CS24.1 General

CS24.1.1 Application

1 With respect to the provisions of **24.1.1-2**, **Part CS** of the Rules, ships intended for the carriage of liquid cargoes having a vapour pressure less than 0.28 *MPa* at 37.8°C other than crude oil and oil petroleum products, are to be in accordance with the following.

(1) For tankers carrying liquid cargoes with a specific gravity ρ exceeding 1, the scantlings of structural members composing the cargo oil tank are to be the greater of the values obtained by the following two procedures.

(a) All scantlings calculated in accordance with the relevant requirements of the Rules

(b) Scantlings calculated by structural member type as follows

i) The scantlings of bulkhead plates, stiffeners attached to bulkhead plating, and girders attached to bulkhead plating are to be calculated by multiplying h by ρ before using the formulae specified in **24.3**, **24.4** and **24.7, Part CS** of the Rules.

ii) The scantlings of girders and floors in the double bottom and girders and transverses in the double side hull are to be calculated by multiplying h' by ρ before using the formulae specified in **24.6.3** and **24.6.4, Part CS** of the Rules. Where the load from the cargo oil tank is considered in determining h_i specified in **C24.5.1(1)**, the load is to be multiplied by ρ.

iii) The values of ρ are to be determined for respective cases unless shown in **Table CS24.1.1-1**.

(2) For tankers carrying dangerous chemicals in bulk, the requirements in **Part S** of the Rules are also to be applied.

Table CS24.1.1-1 Values of ρ

Cargo	ρ
Molasses	1.4
Asphalt	1.1
Concentrated sulphuric acid	1.85

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.

CS24.1.2 Location and Separation of Spaces

1 Size and arrangement of cargo oil tanks and segregated ballast tanks.

The size and arrangement of cargo oil tanks and segregated ballast tanks are to comply with the requirements of **3.2.1, Part 3 of the Rules for Marine Pollution Prevention Systems**.

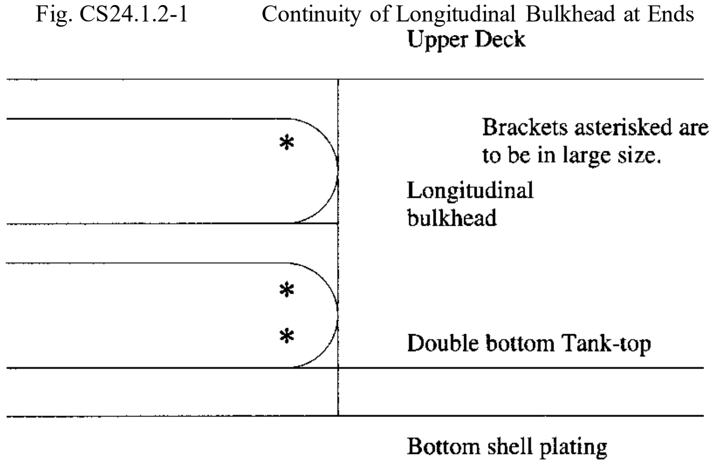
2 Restriction on arrangements of double hull structures and double bottom structures

Arrangements of double side hulls and double bottoms are to comply with the requirements of **3.2.4, Part 3 of the Rules for Marine Pollution Prevention Systems**.

3 Continuity of longitudinal bulkhead

At the forward and afterward ends of cargo oil tanks, precautions are to be taken to keep continuity between the ends of longitudinal bulkheads and the longitudinal members of the deck. (*See* **Fig. CS24.1.2-1**)

Fig. CS24.1.2-1 Continuity of Longitudinal Bulkhead at Ends



4 Cofferdams and bulkheads bounding cargo oil tanks

(1) "Cofferdam" referred to in **24.1.2-2, Part CS** of the Rules means an isolating void space between two adjacent steel bulkheads or decks. In case of the cofferdam between bulkheads, it is to be arranged to keep the minimum distance of 600 *mm* between bulkheads.

(2) Where a cargo oil tank is adjacent to the fore peak (fore peak tank), the collision bulkhead is to be free from openings. (*See* **14.3.2** and **14.3.3, Part D** 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).

(4) Electrical equipment is to be dealt with referring to the relevant requirements in **Chapter 4, Part H** of the Rules.

5 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 a watertight bulkhead in ships of not less than 100 *m* in length and of an airtight bulkhead in ships of less than 100 *m* in length.

(2) The following values are standard for scantlings of airtight bulkheads for which no hydrostatic tests are required. Airtightness tests may be replaced by hose tests. 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. The section modulus of stiffeners and girders is to be 50% of the Rule requirements for watertight bulkheads. Where connected to the shell and decks, however, these stiffening members are to have the same effectiveness as frames and beams.

6 Superstructures and deckhouses

The deckhouse protecting the entrance to pump rooms is to be in accordance with the following requirements.

(1) The strength of the front wall is to be equivalent to that of the wall of the bridge.

(2) The strength of side walls and after wall are to be equivalent to that of the front wall of the poop.

(3) The height of doorway coamings is not to be less than 600 *mm* above the freeboard deck. However, the height may be reduced to not less than 450 *mm* for ships with a class notation of *Coasting Service*.

CS24.3 Bulkhead Plating

CS24.3.2 Swash Bulkheads

1 Arrangements of swash bulkheads

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. 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.

It is not to be less than 2.0.

CSh_sl^2 (cm^3)

Where:

S: Spacing (m) of stiffeners

l: Span (m) of stiffener between supports

C: Coefficients given below:

Both ends effectively bracketed: 7.1

One end effectively bracketed and the other end supported by girder: 8.4

Both ends supported by girders: 10.0

h_s: Value obtained from the following formula

It is not to be less than 2.0.

$$\underline{\left(0.176 - \frac{0.025}{100}L\right)(1-\alpha)l_t}$$

Where:

L: Length (m) of ship

α: Opening ratio of bulkhead plating

l_t: Length (m) of tank

(4) In applying the requirements of **24.7.1-1** to **24.7.1-3, Part CS** 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)**.

CS24.9 Structural Details

CS24.9.4 Supporting Structures of Independent Prismatic Tanks

1 General

With respect to the provisions of **24.9.4, Part CS of the Rules,** the arrangement and scantlings of the supporting structures of the independent prismatic tanks are to comply with the requirements of this paragraph. However, other methods approved by the Society may be acceptable.

2 Strength Criteria

Compressive stress σ_a (N/mm^2) acting on each plate which composes the supporting structures, excluding top plate, is to comply with the following criteria:

$\sigma_a < \sigma_{cr}$

σ_a: The compressive stress acting on each plate which composes the supporting structures, excluding top plate, as given by the following:

$$\sigma_a = \frac{F_a}{A_{\min}} \quad (N/mm^2)$$

F_a: Load acting on the supporting structures as given by the following:

$F_a = 1000\rho V_t(1+a_z)g$ (N)

ρ : Cargo density (ton/m^3)

V_t: Tank volume (m^3) supported by the supporting structure under consideration

a_z: Maximum dimensionless vertical acceleration (i.e. relative to the acceleration of gravity) acting on the centre of the cargo tank under consideration obtained from the following formula. a_z does not include the component due to the static weight.

$$a_z = \pm a_0\sqrt{1+\left(5.3-\frac{45}{L}\right)^2\left(\frac{x}{L}+0.05\right)^2\left(\frac{0.6}{C_b}\right)^{1.5}}$$

a_0: As obtained from the following formula:

$$a_0 = 0.2\frac{V}{\sqrt{L}} + \frac{34 - \frac{600}{L}}{L}$$

V : Ship speed (*kt*) as define in **2.1.8, Part A of the Rules**

x : Longitudinal distance (*m*) from amidships to the centre of gravity of the cargo tank; x is positive forward of amidships, negative aft of amidships

g: Acceleration due to gravity to be taken as 9.81 (m/s^2)

$A_{\min}$: Minimum horizontal sectional area (mm^2) which is obtained by subtracting 0.5 *mm* from all side of the plates (*See* **Fig.CS24.7.4-1**)

σ_{cr}: Allowable stress obtained by the following value, whichever is the lesser:

$\frac{\sigma_{yd}}{1.33}$ (N/mm^2)

$C_x\sigma_{yd}$ (N/mm^2)

σ_{yd}: Yield stress (N/mm^2) of the material used for the supporting structures

C_x : Reduction factor for each plate which composes the supporting structures, excluding top plate, as obtained by **Table CS24.7.4-1**. Assessed plate which is not rectangular may be approximated using **Table CS24.7.4-2**.

Fig. CS24.7.4-1 Example of Supporting Structure (Excluding Top Plate) and the Relevant Minimum Horizontal Sectional Area

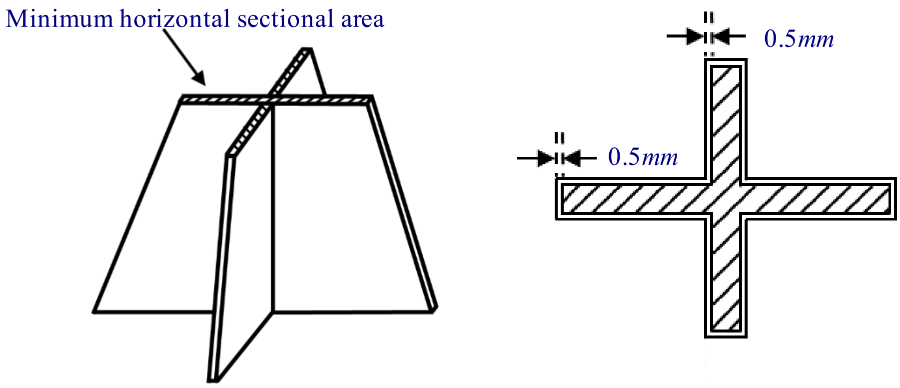
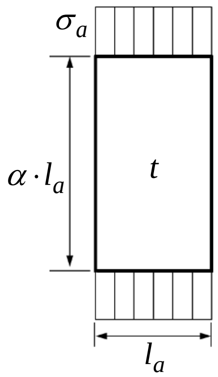
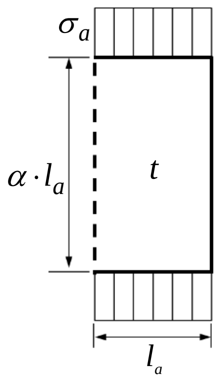


Table CS24.7.4-1 Reduction Factor for Plane Plate Panels

	Aspect ratio α	Buckling factor K	Reduction factor C_x
1 	$\alpha \geq 1$	$K = 4$	$C_x = 1$ for $\lambda \leq 0.8$ $C_x = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.8$
2 	$\alpha > 0$	$K = 0.425 + \frac{1}{\alpha^2}$	$C_x = 1$ for $\lambda \leq 0.7$ $C_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$

Explanations for boundary conditions:

- - - - - plate edge free

——— plate edge simply supported

λ: Reference degree of slenderness, to be taken as:

$$\lambda = \sqrt{\frac{\sigma_{yd}}{K\sigma_E}}$$

σ_E: Reference stress (N/mm^2), to be taken as:

$$\sigma_E = 0.9E\left(\frac{t}{l_a}\right)^2$$

E: Modulus of elasticity, 206,000 (N/mm^2)

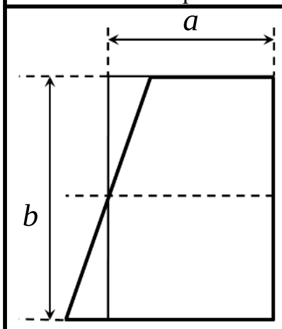
t : As obtained from the following formula

$$t = t_{as-built} - 1.0 \ (mm)$$

$t_{as-built}$: As-built thickness (mm)

l_a: Length of the side of the plate panel (mm)

Table CS24.7.4-2 Trapezoidal Panel Approximation

Shape	Approximation
	A rectangle is derived with *a* being the mean value of the bases and *b* being the height of the original panel.

CS24.11 Special Requirements for Hatchways and Freeing Arrangements

CS24.11.5 Freeing Arrangement

1 Effective freeing arrangement

Open guardrails installed on more than half the length of the exposed parts of the freeboard deck may be replaced by freeing ports in the lower parts of the bulwarks, for at least 33% of the total area of bulwarks.

CS25 LOADING MANUAL

CS25.1 General

CS25.1.1 General

1 "Ships deemed appropriate by the Society" as stipulated in **25.1.1-2, Part CS** of the Rules, refers to the following types of ships when their maximum deadweight does not exceed 30 % of their maximum displacement.

(1) Ships with an arrangement that allows only small possibilities of variation in the distribution of cargo and ballast.

(2) Ships in regular service that perform standard loading. However, it is to be clearly stated either in the "Stability Information" as stipulated in **2.1.7-8(1), Part B** of the Rules, or in some other suitable document that no non-standard loading is to be performed.

(3) Ships other than those stipulated in **3.8.1.1-2, Part 1, Part C** of the Rules.

2 For ships not required to be provided with a loading manual, the precautions for loading, such as the maximum allowable cargo weight on deck, are to be recorded either in the "Stability Information" as stipulated in **2.1.7-8(1), Part B** of the Rules, or in some other suitable document.

CS25.1.2 Loading Manual

1 The loading manual approved by the Society according to **25.1.2, Part CS of the Rules**, is to be prepared in compliance with **Annex3.8, Part 1, Part C of the Rules.** The manual is to be written with a language easily understood by the ship master. Where this language is not English, a translation into English is to be included.

2 The "standard loading conditions" specified in **25.1.2, Part CS of the Rules**, are the loading conditions specified for each ship type in **An1.3** of **Annex 3.8, Part 1, Part C of the Rules**.

CS26 MEANS OF ACCESS

CS26.1 General Rules

CS26.1.1 General

1 Means of access specified in **26.1.1**, **Part CS** of the Rules are arranged for the purpose of detecting disorders such as damage, corrosion, etc. which may occur on the boundaries of compartments and important internal structural members fitted thereon, such as transverse rings, web frames, girders, struts, etc. at an early stage. Accordingly, the arrangement is to be such that any one side of these members can be easily and safely inspected from within a distance of not more than 3 *m*. This distance may be properly modified, depending on the actual conditions, when easy access and/or ample illumination is available.

2 The means of access may be those permanently fixed to the hull, such as stagings, walkways, ladders, and steps (hereinafter, referred to as "permanent means of access") and those that are prepared for temporary use, such as inflatable rafts and portable ladders. Where structural members can be utilized as stagings or walkways, they can be regarded as permanent means of access.

CS26.1.2 Means of Access to Spaces

1 With respect to the provisions of **26.1.2**, **Part CS** of the Rules, permanent means of access where deemed as impracticable by the Society may be placed with portable ladders.

2 The openings of hatches or manholes for the means of access to the hold spaces for independent tanks are to be not less than those required by **g.** of **Table CS26.1.2**.

CS26.1.3 Means of Access within Spaces

1 With respect to the provisions of **26.1.3**, **Part CS** of the Rules, the following spaces and places are to be provided with permanent means of access.

(1) Fore peak tanks

(2) Aft peak tanks

(3) Cofferdams

(4) One side tank situated at or near the forward end of the parallel body of the hull and one or more tank(s) in other parts (water ballast tank if possible)

(5) Any one or more tank(s) from among centre tanks

(6) Watertight and oiltight bulkheads having horizontal girders

(7) Cargo holds with bilge hopper tanks whose height is over 3 *m* at side from the top of inner bottom plates to upper end of bilge hopper tanks

2 The permanent means of access in the spaces and places prescribed in **-1** above are to be arranged in accordance with the following:

(1) In side tanks, ladders or steps are to be so arranged that all corners and structural ends of one or more transverse ring(s) (preferably at mid-tank) can be inspected.

(2) In centre tanks, ladders or steps are to be so arranged that both ends of one or more bottom transverse(s) (preferably at mid-length of tank) can be inspected.

(3) For watertight and oiltight bulkheads with horizontal girders, ladders or steps are to be arranged for access to such girders.

(4) Ladders or steps for access to a height up to about 1.5 *m* above the bottom or a horizontal girder may be omitted where access is available by means of longitudinal frames, horizontal stiffeners, etc.

(5) On both sides of each cargo hold specified in **-1(7)** above at the forward, middle and aft parts, ladders (or steps) and hand rails are to be available for inspection of lower parts of hold frames together with their end brackets. Hand rails are to be fitted within the spaces between three hold frames at least. However, a portable ladder may be acceptable instead of fixed ladders (or steps) and hand rails may be omitted subject to approval by the Society.

3 The clearances for inspections and means of access within the hold spaces for independent tanks is to be not less than those required by **a.** to **f.** of **Table CS26.1.2**.

Table CS26.1.2

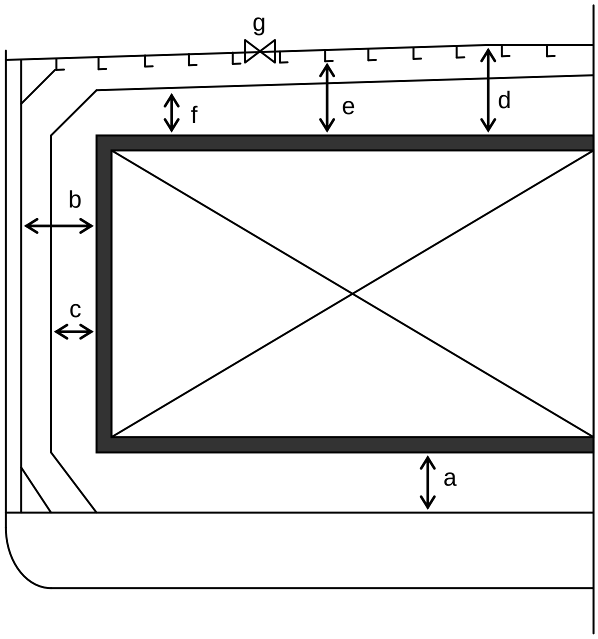
Location[1]	ships not less than 5,000 tonnes deadweight	ships less than 5,000 tonnes deadweight
a. insulation ~ inner bottom plate	600 *mm*	600 *mm*
b. insulation ~ side frame	600 *mm*	450 *mm*
c. insulation ~ girder	450 *mm*[2]	450 *mm*[2]
d. insulation ~ upper deck	600 *mm*	600 *mm*
e. insulation ~ deck beam	600 *mm*	450 *mm*
f. insulation ~ deck girder	450 *mm*[2]	450 *mm*[2]
g. horizontal opening	600 *mm* ×600 *mm*	500 *mm* ×500 *mm*

Notes:

(1) Refer to **Fig. CS26.1.2** for the relevant locations

(2) Where openings are provided in order to make the relevant location readily accessible from each side, it may be 0.5 times the width of face plate or 50 *mm*, whichever is smaller.

Fig. CS26.1.2



CS26.1.4 Specifications of Means of Access and Ladders

1 Means of access that are safe to use referred to in **26.1.4-1, Part CS** of the Rules mean those meeting the following conditions.

(1) Ladders and steps are not to be fitted on a surface which is unnecessarily outside the inside line of the hatch coaming.

(2) Hand grips are to be provided appropriately.

(3) Ladders and steps are to be extended upward and downward as deemed necessary.

(4) No hollows are to be allowed in flights of ladders.

2 With respect to the provisions of **26.1.4, Part CS** of the Rules, stagings and walkways forming sections of permanent means of access are to be constructed as follows.

(1) The clear width of stagings and walkways is not to be less than 600 *mm*, except for going around vertical webs where the minimum clear width may be reduced to 450 *mm*, and have guard rails over the open side of their entire length.

(2) Elevated passageways forming sections of a permanent means of access are to be provided with guard rails of 750 *mm* in height on the open side.

(3) Where horizontal girders or similar structures are utilized as stagings, etc., lightening holes of a diameter exceeding 100 *mm* are to have fixed gratings.

3 With respect to the provisions of **26.1.4, Part CS** of the Rules, ladders and steps utilized for permanent means of access are to be constructed as follows.

(1) The width of ladders and steps is to be not less than 250 *mm* and the distance from the wall to the free edge of footsteps, not

less than 120 *mm*. Footsteps are to be arranged at a regular interval not less than 250 *mm* but not more than 350 *mm*, or of an equivalent arrangement.

(2) Landings are to be provided at an interval not exceeding 9 *m* on vertical ladders and at a vertical interval of 12 *m* on inclined ladders.

4 Where portable ladders are utilized in accordance with the provisions of **CS26.1.3-2(5)**, appropriate measures such as horizontal bars which are provided between two transverse frames for hanging a ladder, are to be taken for their safe use.

5 Where rafts are utilized for means of access, they are to comply with the following conditions.

(1) The tanks are to have pumping arrangements for filling and discharging a capacity appropriate for ordinary water ballast tanks.

(2) Where swash bulkheads are provided in the tank, they are to have openings for passage in their upper part, or each part that is separated from others by such swash bulkheads is to have an access hatch or manhole. The dimensions of these hatches or manholes may be determined assuming that rafts will be inflated in the tanks.

(3) The raft is to be capable of carrying 3 persons, and where an inflatable type is used, be able to stay afloat safely even if one of the airtight chambers is broken. A ship is to have at least one raft, but it is recommended to have at least two.

CS26.2 Special Requirements for Oil Tankers

CS26.2.1 Application

1 With respect to the provisions of **26.2**, **Part CS of the Rules**, this regulation does not apply to oil tankers other than those having integral tanks for the carriage of oil in bulk. Even in cases where the provisions of **26.2**, **Part CS of the Rules** are applied, **CS26.1.2-2** and **CS26.1.3-3** are also to be applied to the means of access to the hold spaces for independent tanks as well as and to the means of access within said hold spaces.

CS26.2.2 General

1 For the purpose of **26.2, Part CS** of the Rules, appropriate means of access are to be provided to enable close-up examinations of positions where close-up examinations and thickness measurements are required in accordance with the provisions of **Part B** of the Rules and positions with critical structural areas. In application, "critical structural areas" are locations which have been identified from calculations to require monitoring or from the service history of similar or sister ships to be susceptible to cracking, buckling, deformation or corrosion which would impair the structural integrity of the ship. Each space for which close-up inspection is not required such as fuel oil tanks and void spaces forward of cargo area, may be provided with a means of access necessary for overall survey intended to report on the overall conditions of the hull structure.

2 For the purpose of **26.2**, **Part CS** of the Rules, the following definitions apply.

(1) Rung means the step of a vertical ladder or step on a vertical surface.

(2) Tread means the step of an inclined ladder or step for a vertical access opening.

(3) Flight of an inclined ladder means the actual stringer length of an inclined ladder. For vertical ladders, it is the distance between the platforms.

(4) Stringer means either:

  (a) The frame of a ladder

  (b) The stiffened horizontal plating structure fitted on the side shell, transverse bulkheads and/or longitudinal bulkheads in the space

  For the purpose of ballast tanks of less than 5 *m* width forming double side spaces, the horizontal plating structure is credited as a stringer and a longitudinal permanent means of access, if it provides a continuous passage of 600 *mm* or more in width past frames or stiffeners on the side shell or longitudinal bulkhead. Openings in stringer plating utilized as permanent means of access shall be arranged with guard rails or grid covers to provide safe passage on the stringer or safe access to each transverse web.

(5) Vertical ladder means a ladder of which the inclined angle is 70 *degrees* and over up to 90 *degrees*. A vertical ladder shall not be skewed by more than 2 *degrees*.

(6) Overhead obstructions mean the deck or stringer structure including stiffeners above the means of access.

(7) Distance below deck head means the distance below the plating.

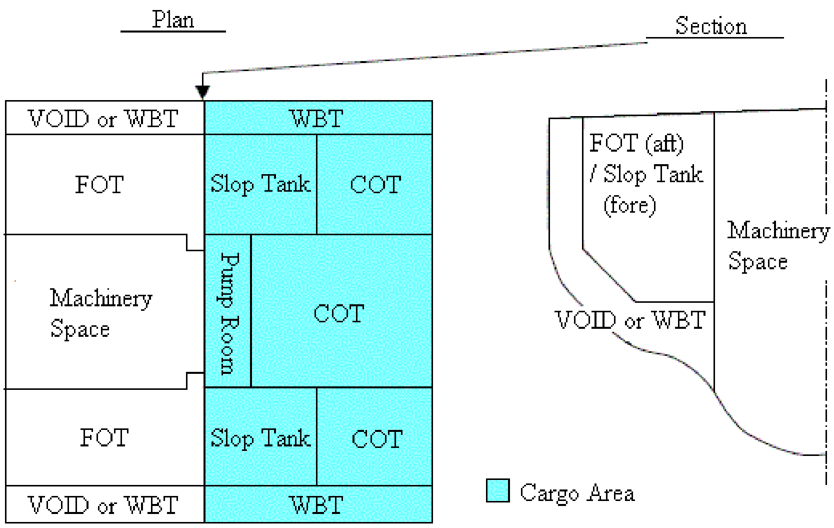
(8) Cross deck means the transverse area of the main deck which is located inboard and between hatch coamings.

(9) Cargo area means either:

(a) For oil tankers, area as defined in **2.1.35**, **Part A** of the Rules but excluding deck areas
However, spaces protecting oil fuel tank(s) in the machinery space as shown in **Fig. CS26.2.2** need not be applicable to the provisions of **26.2, Part CS** of the Rules, even though they have a cruciform contact with the cargo oil tank or slop tank.

(b) For bulk carriers, cargo spaces and other spaces such as ballast tanks, cofferdams and void spaces within cargo spaces or adjacent to cargo spaces in the ship's transverse section

Fig. CS26.2.2



CS26.2.3 Means of Access to Spaces

1 With respect to the provisions of **26.2.3**, **Part CS** of the Rules, the vertical distance between deck and horizontal stringer; horizontal stringers; deck or horizontal stringer and the bottom of the space; deck or horizontal stringer and platform; and platforms means the vertical distance between the upper surface of the lower deck, horizontal stringer or platform and the lower surface of the upper deck, horizontal stringer or platform

2 With respect to the provisions of **26.2.3**, **Part CS** of the Rules, special attention is to be paid to the structural strength where any access opening is provided in the main deck or cross deck.

3 With respect to the provisions of **26.2.3-2, Part CS** of the Rules, the wording "not intended for the carriage of oil or hazardous cargoes" applies only to "similar compartments", and access may be from pump-rooms, deep cofferdams, pipe tunnels, cargo holds and double hull spaces.

4 "Deck" specified in **26.2.3-3, Part CS** of the Rules means "weather deck".

5 With respect to the provisions of **26.2.3-4, Part CS** of the Rules, where deemed necessary for aligning resting platform arrangements with hull structures, the vertical distance from the deck to a platform, between such platforms, or a platform and the tank bottom may be not more than 6.6 *m*.

6 With respect to the provisions of **26.2.3-4(2)** and **(4), Part CS of the Rules**, adjacent sections of a vertical ladder are to be in accordance with following **(1)** to **(3)**. (Refer to **Fig. CS26.2.3-1**, **Fig. CS26.2.3-2** and **Table CS26.2.3**)

(1) The minimum "lateral offset" between two adjacent sections of a vertical ladder is the distance between the sections, upper and lower, so that the adjacent stringers are spaced at least 200 *mm* apart, measured from half thickness of each stringer.

(2) Adjacent sections of vertical ladder are to be installed so that the upper end of the lower section is vertically overlapped, in respect to the lower end of the upper section, to a height of 1,500 *mm* in order to permit a safe transfer between ladders. However, this requirement does not apply to cases where structural members (e.g. side stringers) are used to move between adjacent vertical ladders and are provided with safety measures such as handrails.

(3) No section of the access ladder is to be terminated directly or partly above an access opening.

Fig. CS26.2.3-1 Vertical Ladder – Ladder Passing through Linking Platform

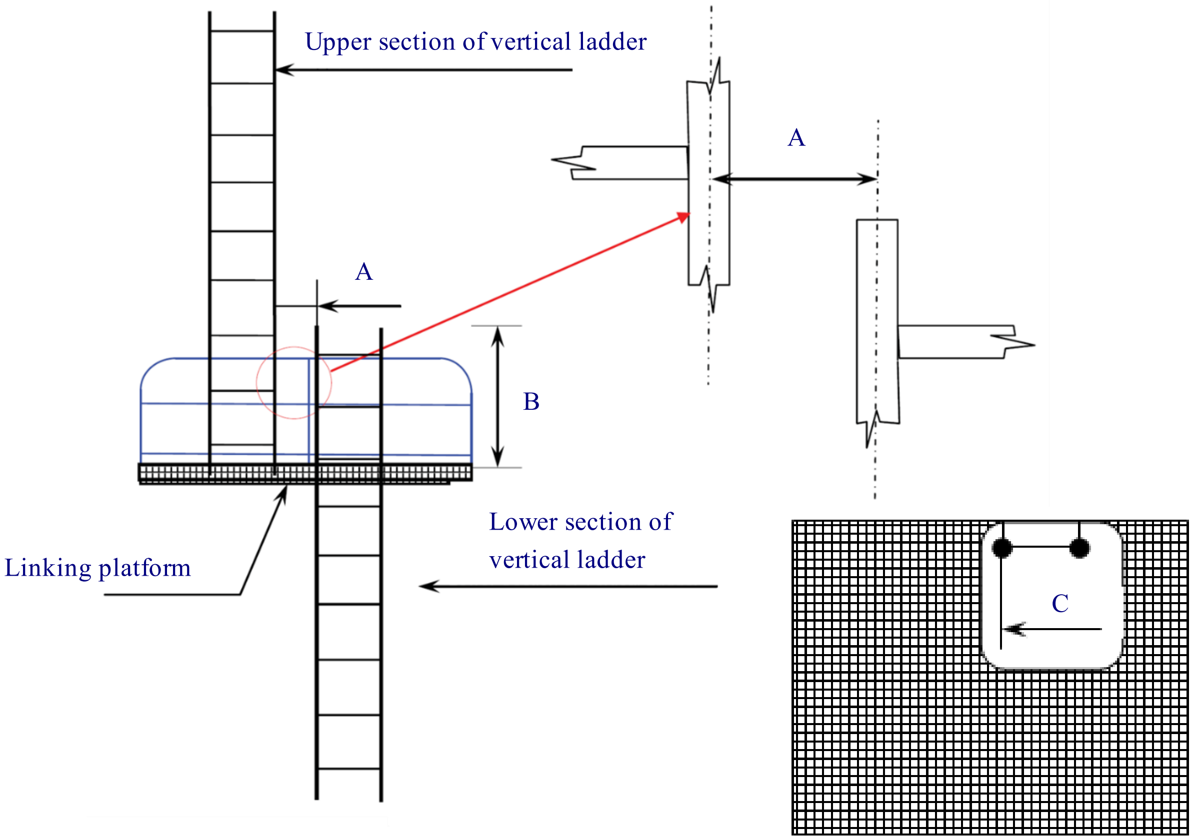


Fig. CS26.2.3-2 Vertical Ladder - Side Mount

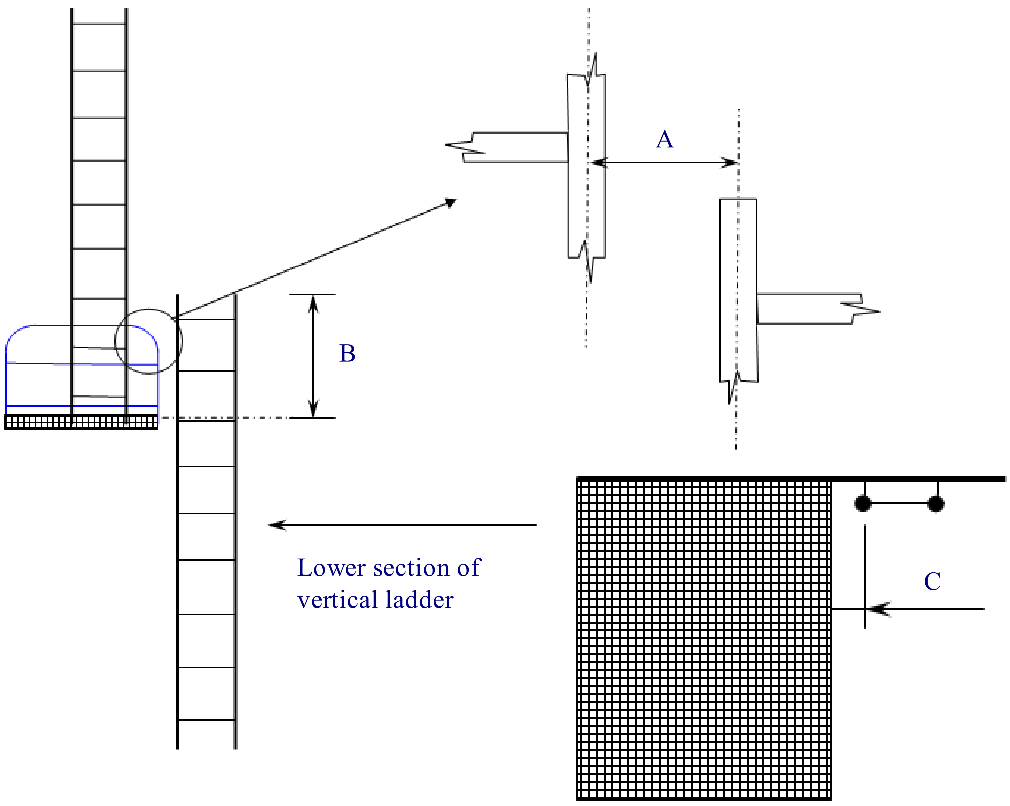


Table CS26.2.3 Dimensions

A	Horizontal separation between two vertical ladders, stringer to stringer	≥ 200 *mm*
B	Stringer height above landing or intermediate platform	≥ 1,500* *mm*
C	Horizontal separation between ladder and platform	100 *mm* ≤ C < 300 *mm*
Note * : the minimum height of the handrail of resting platform is 1,000 *mm*		

CS26.2.4 Means of Access within Spaces

1 Alternative means of access specified in **26.2.4, Part CS** of the Rules include, but are not limited to, such devices as:

(1) Hydraulic arm fitted with a stable base

(2) Wire lift platform

(3) Staging

(4) Rafting

(5) Robot arm or remotely operated vehicle (*ROV*)

(6) Portable ladders more than 5 *m* long are only to be utilized if fitted with a mechanical device to secure the upper end of the ladder. Where hooks for securing at the upper end of a ladder are provided as a mechanical device, such hooks are to be designed so that a movement fore/aft and sideways can be prevented at the upper end of the ladder

(7) Other means of access, approved by and acceptable to the Society

2 With respect to the provisions of **26.2.4, Part CS** of the Rules, the selection of an alternative means of access is to be based on the following conditions. Refer to **Annex 14.16, Part 1, Part C of the Rules** for details.

(1) Such means provide accessibility and safety equivalent to permanent means

(2) Such means are suitable for use in an environment of the intended spaces

(3) Where the use of means such as *ROV* for the inspection of under deck structures, such means can be introduced into the space directly from a deck access

(4) Such means comply with or are based on appropriate safety standards

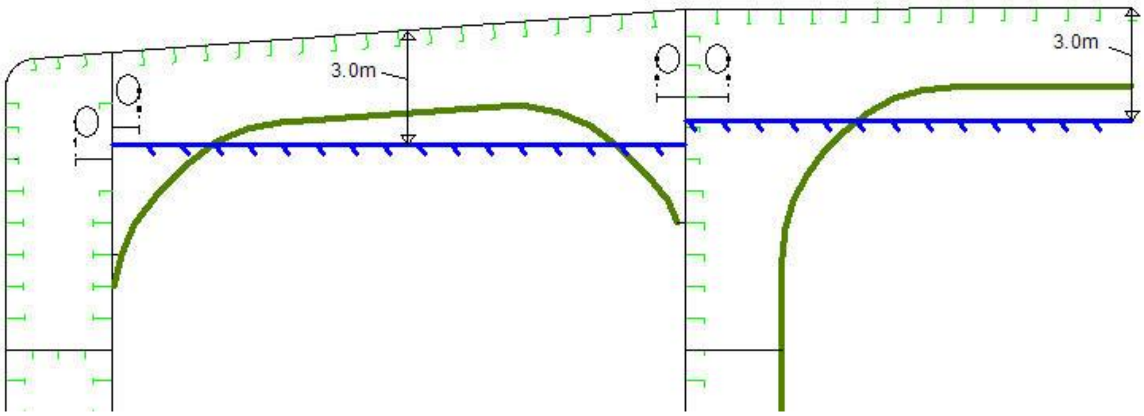
(5) Where the use of means other than those specified in **CS26.2.4-1(3)**, **(4)** or **(6)**, such means are approved by the Administration and the ship's owner

3 Where a boat is used as an alternative means, **CS26.1.4-5** is to apply. Rafts or boats alone may be allowed for survey of the under deck areas for tanks or spaces if the depth of the webs is not more than 1.5 *m*. If the depth of the webs is more than 1.5 *m*, rafts or boats alone may be allowed only if permanent means of access are provided to allow safe entry and exit. This means either:

(1) Access direct from the deck via a vertical ladder and small platform approximately 2 *m* below the deck in each bay

(2) Access to the deck from a longitudinal permanent platform having ladders to the deck at each end of the tank
The platform is to, for the full length of the tank, be arranged at or above the maximum water level needed for rafting of the under deck structure. For this purpose, the ullage corresponding to the maximum water level is to be assumed not more than 3 *m* from the deck plate measured at the midspan of the deck transverses and in the middle of the length of the tank. (Refer to **Fig. CS26.2.4**) A permanent means of access from the longitudinal permanent platform to the water level indicated above is to be fitted in each bay (*e.g.*, permanent rungs on one of the deck webs inboard of the longitudinal permanent platform).

Fig. CS26.2.4 Use of Rafts/Boats



4 With respect to the provisions of **26.2.4**, **Part CS** of the Rules, it is to be demonstrated that portable means for inspection can be deployed and made readily available in the areas where needed.

5 For the purpose of **26.2.4, Part CS** of the Rules, the height of a space means the vertical distance between the top surface of the bottom plate of the space and the lower surface of the top plate of the space. In general, the height is to be measured from the lowest position to the highest position in each tank. However, for a space the height of which varies at different bays/sections, the requirements of **26.2.4, Part CS** of the Rules may be applied to such bays/sections of that space which fall under the criteria.

6 With respect to the provisions of **26.2.4**, **Part CS** of the Rules, special attention is to be paid to the structural strength where any access opening is provided in the structural members.

7 Unless stated otherwise in **26.2.4**, **Part CS** of the Rules, vertical ladders that are fitted on vertical structures for inspection are to comprise of one or more ladder linking platforms spaced not more than 6 *m* apart vertically and displaced to one side of the ladder. Adjacent sections of ladder are to be laterally offset from each other by at least the width of the ladder. For the purpose of complying with the above, adjacent sections of ladders are to be in accordance with **CS26.2.3-6**.

8 The requirements of **26.2.4-1**, **Part CS** of the Rules are also to be applied to void spaces in the cargo area, comparable in volume to cargo tanks and ballast tanks.

9 In the application of **26.2.4-1(1)**, **Part CS** of the Rules, the provisions of **(a)** to **(c)** define access to underdeck structures and the provisions of **(d)** to **(f)** define access to vertical structures. These provisions are linked to the presence of underdeck structures and transverse webs on longitudinal bulkheads. If there are no underdeck structures (deck longitudinals and deck transverses) but there are vertical structures in the cargo tank supporting transverse and longitudinal bulkheads (including brackets supporting deck transverses), in addition to access in accordance with applicable provisions of **(d)** to **(f)** of **26.2.4-1(1)**, **Part CS** of the Rules, access in accordance with the provisions of **(a)** to **(c)** of **26.2.4-1(1)**, **Part CS** of the Rules is to be provided for inspection of the upper parts of vertical structure on transverse and longitudinal bulkheads. For example, there is need to provide continuous longitudinal permanent means of access in accordance with the provisions of **26.2.4-1(1)(b)**, **Part CS** of the Rules when the deck longitudinals and deck transverses are fitted on the deck but supporting brackets are fitted under the deck.

10 In the application of **26.2.4-1(1)(d)**, **Part CS of the Rules**, for water ballast tanks of 5 *m* or more in width, such as on an ore carrier, side shell plating shall be considered in the same way as "longitudinal bulkhead".

11 Notwithstanding **-1**, for the application of **26.2.4-1(1)(d)**, **Part CS** of the Rules, wire lift platforms or other means which can provide an equal level of safety as permanent means of access specified in that sub-paragraph, are assumed as alternative means of access. However, rafting and permanent fittings for rafting are not permitted as alternatives to the continuous longitudinal permanent means of access specified in **CS26.2.4-1(2)**.

12 "Means of access deemed appropriate by the Society" stipulated in **26.2.4-1(4), Part CS** of the Rules generally presumes the use of boats. The provisions of **-3** above apply.

13 The requirements of **26.2.4-2**, **Part CS** of the Rules also apply to wing tanks designed as void spaces.

14 For the purpose of **26.2.4-2**, **Part CS** of the Rules, the continuous permanent means of access may be a wide longitudinal, which provides access to critical details on the opposite side by means of platforms attached as necessary on the web frames. Where the vertical opening of the web frame is located in way of the open part between the wide longitudinal and the longitudinal on the opposite side, platforms are to be provided on both sides of the web frames to allow safe passage through the web frame.

15 With respect to the vertical distance of 6 *m* specified in **26.2.4-2(1) (a)** and **(b)**, **Part CS** of the Rules, excess of not more than 10% may be accepted as a reasonable deviation, where deemed necessary for the integration of the permanent means of access with the structure itself.

16 Means of access specified in **26.2.4-2(1)(a)**, **Part CS** of the Rules are to be connected to an access ladder from the deck required in **26.2.3-1**, **Part CS** of the Rules. Where two access hatches are required, access ladders at each end of the tank are to lead to the means of access.

17 With respect to the provisions of **26.2.4-2(2)**, **Part CS** of the Rules, notwithstanding the provisions of **-5**, the height of a bilge hopper tank located outside of the parallel part of the ship may be taken as the maximum of the clear vertical distance measured from the bottom plating to the hopper plating of the tank.

18 With respect to the provisions of **26.2.4-2(2)**, **Part CS** of the Rules in regards to the foremost and aftermost bilge hopper ballast tanks with raised bottoms, a combination of transverse and vertical means of access for access to the upper knuckle point for each transverse web may be accepted in place of the longitudinal permanent means of access.

19 With respect to the provisions of **26.2.4-2(2)**, **Part CS** of the Rules, a ladder or ladders are to be provided between the longitudinal continuous permanent means of access and the bottom of the space.

20 With respect to the provisions of **26.2.4-4**, **Part CS** of the Rules, the use of alternative means of access may be accepted where:

(1) Such means provide accessibility and safety equivalent to permanent means

(2) The use of such means are approved by the Administration and the ship's owner

CS26.2.5 Specifications for Means of Access and Ladders

1 With respect to the provisions of **26.2.5-1**, **Part CS** of the Rules, permanent means of access are to be designed so as to ensure sufficient residual strength during the service life of the ship and, in general, the initial corrosion protection which is the same as the hull structural members is to be applied.

2 With respect to the provisions of **26.2.5-3**, **Part CS** of the Rules, slopping structures are structures that are sloped by 5 or more degrees from the horizontal plane when a ship is in the upright position at even-keel. Non-skid construction is to be such that the surface on which personnel walk provides sufficient friction to the sole of boots even when the surface is wet and covered with thin sediment.

3 Details of the guard rails required in **26.2.5-4, Part CS** of the Rules are to be in accordance with the following.

(1) Where guard rails are divided into several parts, the gaps of discontinuous top handrail are not to exceed 50 *mm*. When the top and mid handrails are connected by a bent rail, the outside radius of the bent part is not to exceed 100 *mm* (see **Fig. CS26.2.5-1**).

(2) The gaps between the top handrail and other structural members are not to exceed 50 *mm*.

(3) Where guard rails are divided into several parts, the maximum distance between the adjacent stanchions across the handrail gaps is to be 350 *mm*. However, when the top and mid handrails are connected together, the maximum distance may be 550 *mm* (see **Fig. CS26.2.5-1**).

(4) The maximum distance between the stanchion and other structural members is not to exceed 200 *mm*. However, when the top and mid handrails are connected together, the maximum distance may be 300 *mm* (see **Fig. CS26.2.5-1**).

4 For guard rails required in **26.2.5-4**, **Part CS** of the Rules, use of alternative materials such as *GRP* is to be subject to compatibility with the liquid carried in the tank. Non-fire resistant materials are not to be used for means of access to a space with a view to securing an escape route at high temperatures.

5 The minimum clear opening of 600 *mm* × 600 *mm* specified in **26.2.5-5**, **Part CS** of the Rules is to be rounded appropriately and may have corner radii up to 100 *mm* maximum. Where larger corner radii are adopted for avoiding stress concentration, a larger opening is to be provided so as to ensure accessibility equivalent to a opening of 600 *mm* × 600 *mm*. For example, 600 *mm* × 800 *mm* with 300 *mm* of corner radii may be accepted.

6 The minimum clear opening of 600 *mm* × 800 *mm* specified in **26.2.5-6**, **Part CS** of the Rules is to be rounded appropriately and may have corner radii up to 300 *mm* maximum. Such openings, in general, are to be 800 *mm* in height. However, an opening of 600 *mm* in height and 800 *mm* in width may be accepted as access openings in vertical structures where it is not desirable to make large openings in the structural strength aspects, i.e. girders and floors in double bottom tanks.

7 With respect to the provisions of **26.2.5-6**, **Part CS** of the Rules, an access opening having other dimensions, i.e. an opening as shown in **Fig. CS26.2.5-2**, may be accepted subject to verification of easy evacuation of an injured person on a stretcher.

8 With respect to the provisions of **26.2.5-6**, **Part CS** of the Rules, where the vertical manhole is at a height of more than 600 *mm* above the bottom plate, it is to be demonstrated that an injured person can be easily evacuated.

9 Smaller dimensions of minimum clear opening stipulated in **26.2.5-7**, **Part CS** of the Rules are to be in accordance with **Table S3.4.4, Part S of the Guidance**.

Fig. CS26.2.5-1 Detail of Handrails

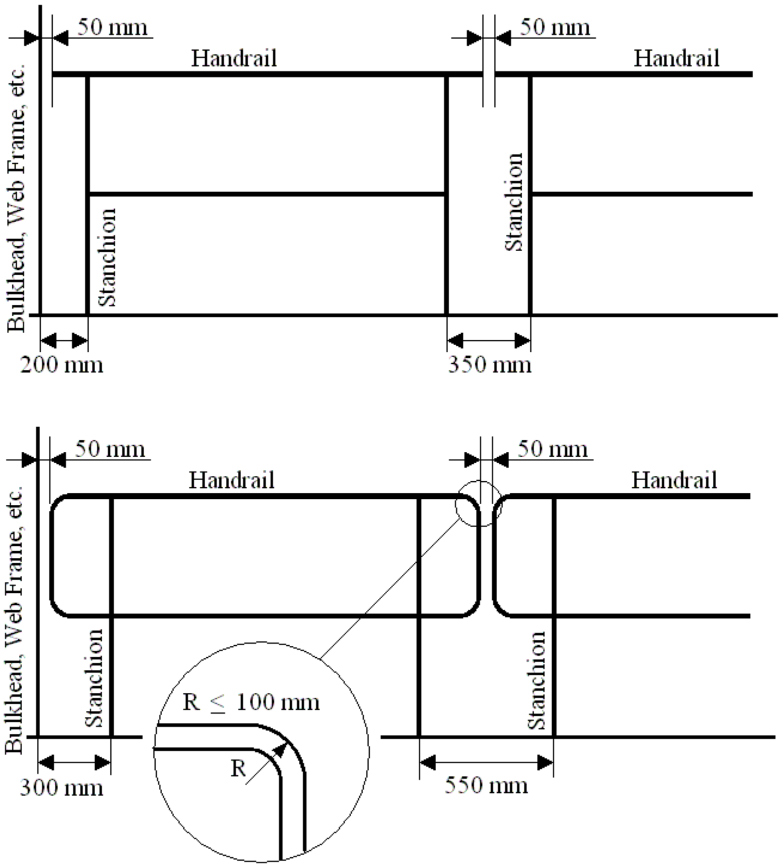
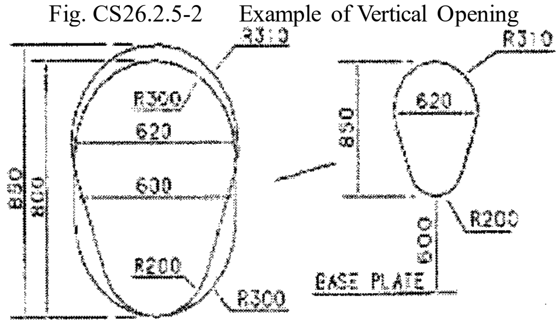


Fig. CS26.2.5-2 Example of Vertical Opening



10 With respect to the provisions of **26.2.5-8**, **Part CS** of the Rules, where the vertical manhole is at a height of more than 600 *mm* above the bottom plate, it is to be demonstrated that an injured person can be easily evacuated.

11 With respect to the provisions of **26.2.5-9**, **Part CS** of the Rules, details of ladders and other means are to be in accordance with the following.

(1) Permanent inclined ladders are to be inclined at an angle of less than 70 *degrees*. There is to be no obstructions within 750 *mm* of the face of the inclined ladder, except that in way of an opening this clearance may be reduced to 600 *mm*. Such clearance is to be measured perpendicular to the face of the ladder. A minimum climbing clearance in width is to be 600 *mm*. For this purpose, handrails may be provided within such climbing clearance. Resting platforms of adequate dimensions are to be provided,

normally at a maximum of 6 *m* vertical height. Where deemed necessary for aligning resting platform arrangements with hull structures, the vertical distance from deck to such platforms, between such platforms or such platforms and the tank bottom may be not more than 6.6 *m*. In this case, the flights of inclined ladders are not to be more than 9 *m* in actual length. Ladders and handrails are to be constructed of steel or equivalent material of adequate strength and stiffness and securely attached to the structure by stays. The method of support and length of stay is to be such that vibration is reduced to a practical minimum. In cargo holds, ladders are to be designed and arranged so that cargo handling difficulties are not increased and the risk of damage from cargo handling gear is minimized.

(2) The width of inclined ladders between stringers is not to be less than 400 *mm*. The width of inclined ladders for access to a cargo hold in bulk carriers is to be at least 450 *mm*. The treads are to be equally spaced at a distance apart, measured vertically, of between 200 *mm* and 300 *mm*. When steel is used, the treads are to be formed of two square bars of not less than 22 *mm* × 22 *mm* in section, fitted to form a horizontal step with the edges pointing upward. The treads are to be carried through the side stringers and attached thereto by double continuous welding. All inclined ladders are to be provided with handrails of substantial construction on both sides. The vertical height of handrails is not to be less than 890 *mm* from the centre of the step and two course handrails is to be provided where the gap between stringer and top handrail is greater than 500 *mm*.

(3) For vertical ladders, the width and construction are to be in accordance with the following. Other details are to be in accordance with international or national standards accepted by the Society.

(a) The minimum width of vertical ladders is to be 350 *mm*.

(b) The vertical distance between the rungs is to be equal and is to be between 250 *mm* and 350 *mm*.

(c) When steel is used, the rungs are to be formed of single square bars of not less than 22 *mm* × 22 *mm* in section, fitted to form a horizontal step with the edges pointing upward.

(d) Vertical ladders are to be secured at intervals not exceeding 2.5 *m* apart to prevent vibration.

(e) A minimum climbing clearance in width is to be 600 *mm* other than the ladders placed between the hold frames. A clearance of 600 *mm* perpendicular to the ladder is to be kept as far as possible.

(4) For spiral ladders, the width and construction are to be in accordance with international or national standards accepted by the Society.

(5) Resting platforms placed between ladders are to follow the provisions of **26.2.5-1** to **-4**, **Part CS** of the Rules.

(6) Portable ladders are to be in accordance with or are based on appropriate safety standards. No free-standing portable ladder is to be more than 5 *m* long unless accepted by the provisions of **CS26.2.4-1.(6)**.

(7) For the selection of portable and movable means of access, refer to **Annex 14.16, Part 1, Part C of the Rules**.

CS26.2.6 Ship Structure Access Manual

1 The Ship Structure Access Manual required in **26.2.6-1**, **Part CS** of the Rules is to contain at least the following two parts.

(1) Part I

This part is to comprise plans, instructions and inventory required in **26.2.6-1.(1)** to **(7)**, **Part CS** of the Rules and the following matters are to be addressed. This part is to be approved by the Society when any content is changed.

(a) Approval/re-approval procedure for the manual, i.e. any changes of the permanent, portable, movable or alternative means of access within the scope of **26.2**, **Part CS** of the Rules are subject to review and approval by the Society.

(b) Verification of means of access is to be part of a survey for continued effectiveness of the means of access in that space which is subject to the survey.

(c) Inspection of means of access is to be carried out by the crew and/or a competent inspector of the company as a part of regular inspection and maintenance.

(d) Actions to be taken if means of access are found unsafe to use.

(e) In case of use of portable equipment, plans showing the means of access within each space indicating from where and how each area in the space can be inspected.

(2) Part II

This part is to comprise of forms for record of inspections and maintenance, and change of inventory of portable equipment due to additions or replacements after construction. The form in this part is approved by the Society when the ship is under survey for classification during construction.

2 The Ship Structure Access Manual required in **26.2.6-1(8)**, **Part CS** of the Rules is to be prepared in a language(s) which all the crew can understand. As a minimum the English version is to be provided.

3 "Critical structural areas" specified in **26.2.6-1(3)**, **Part CS** of the Rules are to be in accordance with the provisions of **CS26.2.2-1**.

Annex CS1.3.1-1 GUIDANCE FOR HULL CONSTRUCTION CONTAINING HIGH TENSILE STEEL MEMBERS

1.1 General

1.1.1 Application

Where materials of high tensile steel *KA*32, *KD*32, *KE*32, *KF*32 (hereinafter to be referred to as "*HT*32"), *KA*36, *KD*36, *KE*36 and *KF*36 (hereinafter to be referred to as "*HT*36") and *KA*40, *KD*40, *KE*40 and *KF*40 (hereinafter to be referred to as "*HT*40") prescribed in **Chapter 3, Part K** of the Rules are used as structural members, the constructions and scantlings are to comply with the following provisions, in addition to those prescribed in the Rules. Where materials of high tensile steel other than *HT*32, *HT*36 and *HT*40 are used, the constructions and scantlings may be properly modified with due consideration for the mechanical properties of the materials to be used.

1.1.2 Details of Construction

1 Where materials of different strengths are mixed in the hull structure, due consideration is to be given to the stress in the lower tensile materials adjacent to high tensile materials.

2 Where stiffeners of lower tensile material are supported by girders of high tensile material, due consideration is to be given to the stiffness of girders and the dimensions of stiffeners to avoid excessive stress in the stiffeners.

3 For members of high tensile steel, special attention is to be paid to the details of constructions to avoid high concentration of stress.

4 Where materials of high tensile steel are extensively used in the hull structure, its designs are to be subjected to detailed study of strength, and their results are to be submitted to the Society.

1.2 Structural Members

1.2.1 General

1 Scantlings of Structural Members

(1) The scantlings of structural members of high tensile steel are not to be less than that obtained by the methods stipulated under **1.2.2** below.

(2) Where the section modulus of hull girder amidships is reduced by using high tensile steel in accordance with the provisions in **1.3.1-2(1), Part CS** of the Rules, the constructions and scantlings are to comply with the provisions under **1.2.3**, in addition to compliance with **(1)** above, if the strength deck and the bottom are constructed on the longitudinal framing system. If the strength deck or the bottom is constructed on the transverse framing system, the constructions and scantlings are to be subject to Society's special consideration.

2 Expressions

Unless specified otherwise, the expressions employed in this Guidance are to be as stipulated in **(1)** to **(4)** below.

(1) f_{DH} and f_{BH} are to be as follows:

$$f_{DH} = \frac{Z_{Mreq}}{Z_{DH\ ship}}$$

$$f_{BH} = \frac{Z_{Mreq}}{Z_{BH\ ship}}$$

Z_{Mreq}: Section modulus of hull determined according to the requirements in **Chapter 15, Part CS** of the Rules when mild steel is used.

$Z_{DH\ ship}$ and $Z_{BH\ ship}$: Actual hull section moduli at strength deck and bottom respectively.

(2) K is the coefficient corresponding to the kind of steel:

0.78 (for *HT*32)

0.72 (for *HT*36)

0.68 (for *HT*40, however, 0.66 may be taken where a fatigue assessment of the structure is performed to verify compliance with the requirements of the Society.)

The values specified in **1.3.1-4, Part CS** of the Rules (for stainless steel and stainless clad steel)

(3) Plate thickness t_M, section modulus Z_M and moment of inertia I_M are those required by the Rules for members and structures of mild steel, and t_H, Z_H and I_H are those for high tensile steel.

(4) Expressions not stipulated here are to be as defined in relevant provisions in **Part CS** of the Rules.

1.2.2 Determination of Scantlings of Structural Members

1 Double Bottoms

The formulae for determining the scantlings of structural members of the double bottom prescribed in **Chapter 6, Part CS** of the Rules, are to be replaced by the formulae in **Table 1.2-1**.

2 Frames

(1) The formulae for determining the scantlings of frames prescribed in **Chapter 7, Part CS** of the Rules, are to be replaced by the formulae in **Table 1.2-2**.

(2) Lower ends of frames

At the lower ends of hold frames and web frames, their section moduli in a range of about 300 *mm* from the upper end of lower brackets are not to be less than the values determined by the following formula:

$$Z_H = Z_M$$

Where appropriate considerations are given to the construction of the lower ends of frames, however, Z_H may be as determined by the formulae in **Table 1.2-2**.

3 Beams, Pillars and Deck Girders

The formulae in **Chapters 10**, **11** and **12, Part CS** of the Rules, for determining the scantlings of beams, pillars and deck girders are to be replaced by those in **Table 1.2-3**.

4 Watertight Bulkheads

The formulae in **Chapter 13, Part CS** of the Rules, for determining the scantlings of watertight bulkheads are to be replaced by those in **Table 1.2-4**.

5 Deep Tanks

The formulae in **Chapter 14, Part CS** of the Rules, for determining scantlings of deep tanks are to be replaced by those in **Table 1.2-5**.

6 Shell Plating

The formulae in **Chapter 16, Part CS** of the Rules, for shell plating are to be replaced by those in **Table 1.2-6**.

7 Decks

The formulae in **Chapter 17, Part CS** of the Rules, for thickness of deck plating are to be replaced by the following formula:

$$t_H = \sqrt{K}(t_M - 2.5) + 2.5 \quad (mm)$$

1.2.3 Special Rules for Longitudinal Strength Members

1 Application

The provisions under this paragraph apply to the use of high tensile steel for the reduction of the hull girder section modulus in the midship part according to **1.3.1-2(1), Part CS** of the Rules in ships having longitudinally framed strength deck and bottom.

2 Extents of Use of High Tensile Steel

Materials of high tensile steel are to be used in the following parts **(1)** to **(7)**.

(1) Longitudinal strength members from the strength deck or the bottom to the points specified below respectively. (*See* **Fig. 1.2-1** and **Fig. 1.2-2**)

(a) Strength deck part

$$b_D = y_D\left(1 - \frac{1}{f_{DH}}\right) \ (m)$$

Where y_D is the distance (m) from the neutral axis of the cross-section of hull to the strength deck

(b) Bottom part

$$b_B = y_B\left(1 - \frac{1}{f_{BH}}\right) \ (m)$$

Where y_B is the distance (m) from the neutral axis of the cross-section of hull to the top of the keel

(2) Longitudinal strength members on strength deck

(3) Portions as shown in **Fig. 1.2-3** of the deck inside the line of openings

(4) Hatch coamings and their horizontal stiffeners within the extents shown in **Fig. 1.2-4**.

(5) Gutter bars and bilge keels welded to high tensile steel materials

Where bilge keels are of riveted construction, materials except flat bars welded to shell plating do not need to be of high tensile steel.

(6) Doubling plates fitted to longitudinal strength members of high tensile steel for reinforcing openings, etc.

(7) It is recommended that the range of $0.5L$ amidships be constructed of high tensile steel. If the range of $0.5L$ amidships is not covered by high tensile steel, special consideration should be given to the continuity of section modulus of hull girder between the ranges of $0.4L$ and $0.5L$ amidships.

Fig. 1.2-1 High Tensile Steel Used in Deck and Bottom

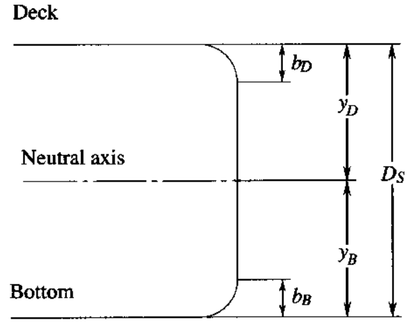


Fig. 1.2-2 High Tensile Steel Used in Deck only

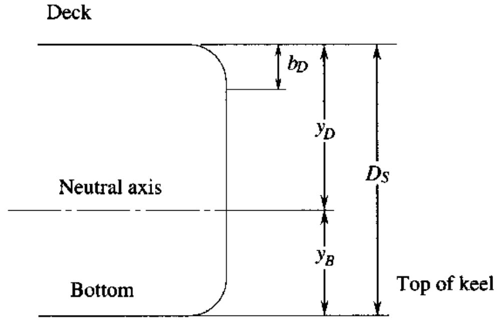


Fig. 1.2-3 Deck

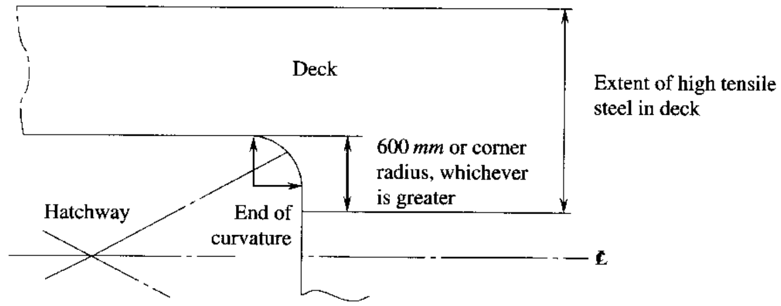
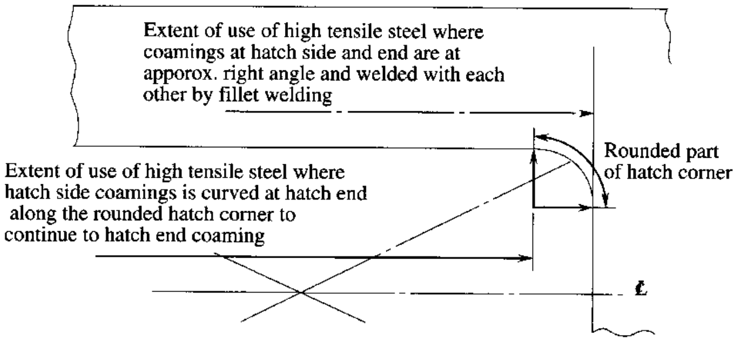


Fig. 1.2-4 Hatch Coaming



3 Scantlings of Structural Members

(1) The scantlings of structural members of high tensile steel are to be in accordance with **(3)** below, in addition to compliance with **1.2.2** above.

(2) The scantlings of structural members of mild steel are to be in accordance with **(3)** below, in addition to compliance with the Rules, provided that f_D and f_B in the formulae in the provisions concerned are to be replaced by f_{DH} and f_{BH} in **1.2.1-2** above respectively.

(3) The ratio of depth to thickness of flat bars used in longitudinal beams and frames, and the slenderness ratio of longitudinal side frames attached to longitudinal beams and shear strakes are to be as specified in the Rules.

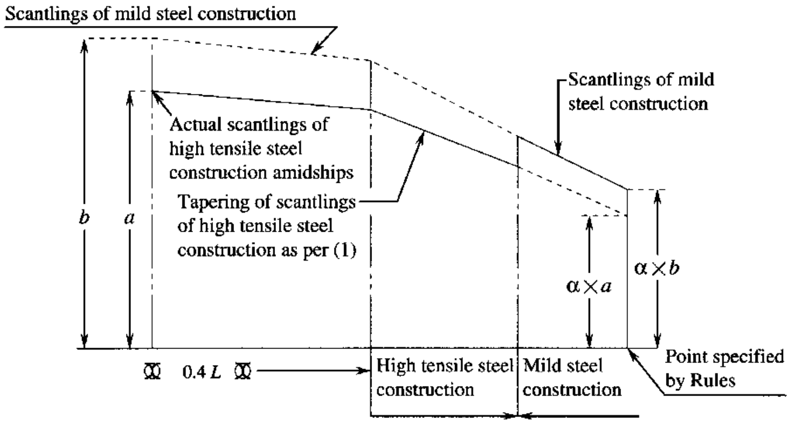
4 Tapering of Longitudinal Strength Members

(1) The manner of tapering of longitudinal strength members of high tensile steel is to comply with the provisions of the Rules, assuming that the entire hull be constructed of high tensile steel.

(2) Where the midship part is constructed of high tensile steel, the scantlings of mild steel members forward of and abaft the midship part are to be in accordance with **Fig. 1.2-5**.

(3) At the connection point of high tensile steel materials and mild steel materials, due consideration should be given to the continuity of strength so that an appreciable difference of plate thickness may be avoided.

Fig. 1.2-5 Scantlings of Mild Steel Members at Fore and Aft Part of Ship



Where:

α: Rule reduction ratio at the point specified by the Rules

a: Actual scantlings of high tensile steel members at the middle of L

b: Scantlings of members at the middle of L for mild steel construction given as follows:

(a) Thickness of shell plating and longitudinal bulkheads

$$\frac{1}{\sqrt{K}}(a - t_c) + t_c \ (mm)$$

t_c: As follows:

Side shell plating

2.5 (mm), for tankers (however, 3.0, where side shell plating forms boundaries of cargo oil tanks planned to carry ballast as well)

2.5 (mm), for other ships

Longitudinal bulkhead

3.5 (mm), for tankers

2.5, for other ships (mm)

(b) Effective sectional area of longitudinal strength members of strength deck

$b = \beta a$

Where β is to be as follows:

For tankers

1.27 (for $HT32$)

1.38 (for $HT36$)

1.46 (for $HT40$)

For other ships

1.34 (for $HT32$)

1.45 (for $HT36$)

1.54 (for $HT40$)

However, where the effective sectional area of longitudinal strength members of the strength deck in the middle of L has been determined, where mild steel construction is assumed, the value may be given as follows:

$$\beta = \frac{S_{e1}}{S_{e2}}$$

S_{e1}: Effective sectional area of the strength deck at the middle of L, where mild steel construction is assumed

S_{e2}: Effective sectional area of the strength deck at the middle of L, for ships made of high tensile steels

(c) Section modulus of stiffeners of longitudinal frames, beams and bulkheads

$$\frac{a}{K}$$

Table 1.2-1 Double Bottoms

Members	Paragraph No.	Scantlings
Open floors	6.5.2-1.	Section modulus: $KCShl^2$ (cm^3)
Bottom longitudinals	6.6.2-1.	Section modulus: $KCShl^2$ (cm^3)
Vertical struts	6.6.3-2.	Sectional area: $2.2KSbh$ (cm^2)
Inner bottom plating	6.7.1.	Thickness of inner bottom plating: $3.8S\sqrt{dK} + 2.5$ (mm)
Longitudinal shell stiffeners & bottom longitudinals in strengthened bottom forward	6.9.4.	Section modulus: $0.53KP\lambda l^2$ (cm^3)

Table 1.2-2 Frames

Members	Paragraph No.	Scantlings
Hold frames	7.3.2.	Section modulus: $Z_H = KZ_M$
Longitudinals on side shell plating	7.4.1.	Section modulus: $Z_H = KZ_M$
Web frames	7.4.2.	Section modulus: $Z_H = KZ_M$ Web thickness: $\frac{C_2K}{1000} \cdot \frac{Shl}{d_1} + 2.5$ (mm)
Tween-deck frames	7.5.2.	Section modulus: $Z_H = KZ_M$
Transverse frames below freeboard decks forward of collision bulkhead	7.6.1.	Section modulus: $Z_H = KZ_M$
Longitudinals below freeboard decks forward of collision bulkhead	7.6.2.	Section modulus: $Z_H = KZ_M$

Table 1.2-3 Beams, Pillars and Deck Girders

Members	Paragraph No.	Scantlings
Longitudinal beams and Transverse beams	10.2.3 10.3.3	Section modulus: $Z_H = KZ_M$
Pillars	11.2.1	Sectional area: $\frac{0.223K\omega}{2.72-\frac{l}{k_0\sqrt{K}}}$ (cm^2)
Deck girders	12.2.1 and 12.3.1 12.2.2 and 12.3.2 12.2.3 and 12.3.3	Section modulus: $Z_H = KZ_M$ Moment of inertia: $I_H = I_M$ Web thickness (i) Longitudinal girders under strength deck outside the line of openings in midship part $10\sqrt{f_{DH}}S_1 + 2.5$ (mm) Other longitudinal and transverse girders $10S_1 + 2.5$ (mm) (ii)Within $0.2l$ from ends $\frac{4.43K}{1000} \cdot \frac{bhl}{d_0} + 2.5$ (mm) $0.813 \cdot \sqrt[3]{\frac{bhlS_1^2}{d_0}} + 2.5$ (mm)

Table 1.2-4 Watertight Bulkhead

Members	Paragraph No.	Scantlings
Bulkhead plating	13.2.1	Thickness: $3.2S\sqrt{Kh}+2.5$ (mm), but not to be less than $5.9S+2.5$ (mm)
Stiffeners	13.2.3	Section modulus: $Z_H=KZ_M$
Girders supporting stiffeners	13.2.5	Section modulus: $Z_H=KZ_M$ Moment of inertia of section: $I_H=KI_M$
Corrugated bulkheads	13.2.9	Thickness: $3.4CS_1\sqrt{Kh}+2.5$ (mm), but not to be less than $5.9CS_1+2.5$ (mm) Section modulus per half pitch: $Z_H=KZ_M$ Plate thickness within $0.2l$ from ends of generating line: Web part $0.0417\frac{CKShl}{d_0}+2.5$ (mm) $1.74\cdot\sqrt[3]{\frac{CShlb^2}{d_0}}+2.5$ (mm) Flange part $\frac{12}{\sqrt{K}}a+2.5$ (mm)

Table 1.2-5 Deep Tanks

Members	Paragraph No.	Scantlings
Bulkhead plating	14.2.2	Thickness: $3.6S\sqrt{Kh}+3.5$ (mm)
Stiffeners	14.2.3	Section modulus: $Z_H=KZ_M$
Girders supporting stiffeners	14.2.4	Section modulus: $Z_H=KZ_M$ Moment of inertia of section: $I_H=KI_M$
Corrugated bulkheads	14.2.8	Thickness: $3.6CS_1\sqrt{Kh}+3.5$ (mm) Section modulus per half pitch: $Z_H=KZ_M$ Plate thickness within $0.2l$ from ends: Web plate $0.0417\frac{CKShl}{d_0}+3.5$ (mm) $1.74\cdot\sqrt[3]{\frac{CShlb^2}{d_0}}+3.5$ (mm) Flange plate $\frac{12}{\sqrt{K}}a+3.5$ (mm)

Table 1.2-6 Shell Plating

Members	Paragraph No.	Scantlings
Shell plating under strength deck	16.3.1	Minimum thickness: $(0.044L + 5.6)\sqrt{K}$ (mm)
Side shell	16.3.2	Thickness for transverse framing system: $4.1S\sqrt{(d + 0.04L)K} + 2.5$ (mm)
Bottom shell	16.3.4	(1) Thickness for transverse framing system: $4.7S\sqrt{(d + 0.035L)K} + 2.5$ (mm) (2) Thickness for longitudinal framing system: $4.0S\sqrt{(d + 0.035L)K} + 2.5 (mm)$
Shell Plating for End Parts	16.4.1	Thickness: $(0.044L + 5.6)\sqrt{K}$ (mm)
Shell Plating for 0.3 L from the Fore End	16.4.2	Thickness: $1.34S\sqrt{KL} + 2.5$ (mm)
Shell Plating for 0.3 L from the After End	16.4.3	Thickness: $1.20S\sqrt{KL} + 2.5$ (mm)
Shell plating at strengthened bottom forward	16.4.4	Thickness: $CS\sqrt{KP} + 2.5$ (mm)