ClassIBS

ISTHMUS BUREAU OF SHIPPING

PART 12
HULL CONSTRUCTION AND EQUIPMENT OF SMALL SHIPS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 12 HULL CONSTRUCTION AND EQUIPMENT OF SMALL SHIPS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 12 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 of *ILLC* do not apply, L_f is to be read as *L* and B_f as *B*.

4. Dry cargo vessels engaged in international voyages and that are not less than 500 *gross tonnage* are to comply with the requirements in **Chapter 30 of Part 2**.

5. Where deemed necessary by the Society, ships coming under the definition of bulk carrier as specified in **28A.1.2(1), Part 2** may be applicable to relevant requirements of **Part 2.**

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

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.

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 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.

1.2.2 Fire-proof Construction and Means of Escape

Fire-proof construction and means of escape are to be in accordance with the requirements in **Part 6.**

1.2.3 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 10**.

2. Where high tensile steels specified in **Chapter 3, Part 10** 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.

1. 0.78: where high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 are used
2. 0.72: where high tensile steels *KA*36, *KD*36, *KE*36 and *KF*36 are used
3. 0.68: where high tensile steels *KA*40, *KD*40, *KE*40 and *KF*40 are used

(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 10** 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 10** 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 0.72.

$$K = f\left\{8.81\left(\sigma_y/1000\right)^2 - 7.56\left(\sigma_y/1000\right) + 2.29\right\}$$

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 10.**

f: To be given by the following formula

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

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.

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 **1.1.9** and **1.1.10, Part 2**. However, the steel grades shown in **Table 1.1** and **Table 1.2** of this Part may be used in lieu of **Table 1.1** and **Table 1.2, Part 2.** Where stainless clad steel specified in **Chapter 3, Part 10** is used for hull construction, the thickness of the base steel is to be used as the thickness of the plate in **Table 1.1** and **Table 1.2, Part 2.**

Table 1.1(a) Application of Mild Steels for Various Structural Members

<table>
<tr><td rowspan="2">Structural member</td><td rowspan="2" colspan="2">Application</td><td colspan="6">Thickness of plate: t (mm)</td></tr>
<tr><td>$t \le 15$</td><td>$15 < t \le 20$</td><td>$20 < t \le 25$</td><td>$25 < t \le 30$</td><td>$30 < t \le 40$</td><td>$40 < t \le 50$</td></tr>
<tr><td colspan="9">Shell plating</td></tr>
<tr><td rowspan="3">Sheer strake at strength deck</td><td colspan="2">within 0.4 L amidship</td><td>A</td><td>B</td><td colspan="2">D</td><td colspan="2">E</td></tr>
<tr><td colspan="2">within 0.6 L 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 0.4 L amidship</td><td>within 0.1 D 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 plating</td><td colspan="2">within 0.6 L 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>Bottom plating including keel plate</td><td colspan="2">within 0.4 L amidship</td><td colspan="2">A</td><td>B</td><td colspan="2">D</td><td>E</td></tr>
</table>

Table 1.1 (b) Application of Mild Steels for Various Structural Members (continued)

Structural member	Application	Thickness of plate: $t(mm)$					
		$t \le 15$	$15 < t \le 20$	$20 < t \le 25$	$25 < t \le 30$	$30 < t \le 40$	$40 < t \le 50$
Deck plating							
Stringer plate in strength deck	within 0.4L amidship	A	B	D		E	
	within 0.6L amidship excluding the above	A		B	D		E
	other than those mentioned above	A				B	D
Strength deck strake adjoining to longitudinal bulkhead	within 0.4L amidship	A	B	D		E	
	within 0.6L amidship excluding the above	A		B	D		E
	other than those mentioned above	A				B	D
Strength deck at cargo hatch corner	within 0.4L amidship	A	B	D		E	
	other than those mentioned above (requiremets for large hatch openings are to be as given in the row above)	A				B	D
Strength deck other than mentioned above	within 0.4L amidship	A		B	D		E
Deck plating exposed to weather, in general	within 0.4L amidship	A				B	D
Longitudinal bulkhead							
Upper strake in longitudinal bulkhead adjoining to strength deck	within 0.4L amidship	A		B	D		E
Lower strake in longitudinal bulkhead adjoining to bottom plate	within 0.4L amidship	A				B	D
Longitudinals							
Upper strake in sloping plate of topside tank adjoining to strength deck	within 0.4L amidship	A		B	D		E
Longitudinal members above strength deck including bracket and face plate of longitudinals	within 0.4L amidship	A		B	D		E

Table 1.1(c) Application of Mild Steels for Various Structural Members (continued)

Structural member	Application	Thickness of plate: $t(mm)$					
		$t \leq 15$	$15<t \leq 20$	$20<t \leq 25$	$25<t \leq 30$	$30<t \leq 40$	$40<t \leq 50$
Cargo Hatch							
Face plate and web of cargo hatch coaming longitudinally extended on the strength deck over 0.15*L*	within 0.4*L* amidship	*A*		*B*	*D*		*E*
Hatch cover	___	*A*				*B*	*D*
Stern							
Stern frame, rudderhorn, shaft bracket	___	*A*				*B*	*D*
Rudder							
Rudder plate	___	*A*				*B*	*D*
Other							
Other members than mentioned above		*A*					

Table 1.2 (a) Application of High Tensile Steels for Various Structural Members

Structural member	Application		Thickness of plate: t (mm)					
			$t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
Shell plating								
Sheer strake at strength deck	within 0.4 *L* amidship		*AH*		*DH*		*EH*	
	within 0.6 *L* amidship excluding the above		*AH*			*DH*		*EH*
	other than those mentioned above		*AH*					*DH*
Side plating	within 0.4 *L* amidship	within 0.1 *D* downward from the lower surface of strength deck	*AH*			*DH*		*EH*
		other than those mentioned above	*AH*					*DH*
Bilge plating	within 0.6 *L* amidship excluding the above		*AH*			*DH*		*EH*
	other than those mentioned above		*AH*					*DH*
Bottom plating including keel plate	within 0.4 *L* amidship		*AH*			*DH*		*EH*

Table 1.2 (b) Application of High Tensile Steels for Various Structural Members (continued)

<table>
<tr><th rowspan="2">Structural member</th><th rowspan="2">Application</th><th colspan="6">Thickness of plate: t(mm)</th></tr>
<tr><th><i>t</i>≤15</th><th>15<<i>t</i>≤ 20</th><th>20<<i>t</i>≤ 25</th><th>25<<i>t</i>≤ 30</th><th>30<<i>t</i>≤ 40</th><th>40<<i>t</i>≤ 50</th></tr>
<tr><td colspan="8">Deck plating</td></tr>
<tr><td rowspan="3">Stringer plate in strength deck</td><td>within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td>within 0.6L amidship excluding the above</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="3">Strength deck strake adjoining to longitudinal bulkhead</td><td>within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td>within 0.6L amidship excluding the above</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">Strength deck at cargo hatch corner</td><td>within 0.4L amidship</td><td colspan="2">AH</td><td colspan="2">DH</td><td colspan="2">EH</td></tr>
<tr><td>other than those mentioned above (requiremets 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>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>within 0.4L amidship</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="8">Longitudinal bulkhead</td></tr>
<tr><td>Upper strake in longitudinal bulkhead adjoining to strength deck</td><td>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>within 0.4L amidship</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="8">Longitudinals</td></tr>
<tr><td>Upper strake in sloping plate of topside tank adjoining to strength deck</td><td>within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>Longitudinal members above strength deck including bracket and face plate of longitudinals</td><td>within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
</table>

Table 1.2(c) Application of High Tensile Steels for Various Structural Members (continued)

Structural member	Application	Thickness of plate: *t*(*mm*)

<table>
<tr><td></td><td></td><td>$t \leq 15$</td><td>$15 < t \leq 20$</td><td>$20 < t \leq 25$</td><td>$25 < t \leq 30$</td><td>$30 < t \leq 40$</td><td>$40 < t \leq 50$</td></tr>
<tr><td colspan="8">Cargo Hatch</td></tr>
<tr><td>Face plate and web of cargo hatch coaming longitudinally extended on the strength deck over 0.15L</td><td>within 0.4L amidship</td><td colspan="3">AH</td><td colspan="2">DH</td><td>EH</td></tr>
<tr><td>Hatch cover</td><td>___</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="8">Stern</td></tr>
<tr><td>Stern frame, rudderhorn, shaft bracket</td><td>___</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="8">Rudder</td></tr>
<tr><td>Rudder plate</td><td>___</td><td colspan="5">AH</td><td>DH</td></tr>
<tr><td colspan="8">Other</td></tr>
<tr><td colspan="2">Other members than mentioned above</td><td colspan="6">AH</td></tr>
</table>

Notes

1 *A, B, D, E* in **Table1.1** and *AH, DH, EH* in **Table 1.2** refer to the following grades of steel:

a. *A:KA, B: KB, D: KD, E: KE*

b. *AH: KA32, KA36 and KA40, DH: KD32, KD36 and KD40, EH: KE32, KE36 and KE40*

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.

1.3.2 Scantlings

1. Section moduli specified by the Rules include the steel plates with an effective breadth of 0.1l on either side of the members, unless specified otherwise. However, the 0.1l 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.

1.3.3 Welding

Welding to be used in hull construction and important equipment is to be in accordance with the requirements in **Part 2 and Part 11.**

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 1.3** 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 800*mm*, 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 1.3 Brackets

(Unit:*mm*)

Lenght of longer arm	Thickness		Breddth flange	Length of longer arm	Thickness		Breddth 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	1000	—	11.5	95
500	11.0	8.5	55	1050	—	12.0	100
550	12.0	8.5	55	1100	—	12.5	105
600	12.5	9.0	65	1150	—	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 Approved Corrosion Control

1. Where an approved measure of corrosion control is applied to tanks, the required scantlings of structural members in the tanks may be reduced at the discretion of the Society.

2. Where the scantlings are reduced in accordance with **-1**, the notation "*CoC*" will be entered in the Classification Register.

1.3.10 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 **1.1.22, Part 2.**

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 1A**.

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 (Lf) is 96% of the length in meters 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 $0.4L$ amidships unless otherwise specified.

1.4.7 End Parts of Ship

The end parts of ship are the parts within $0.1L$ 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 *ILLC*

(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 meters 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 meters 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 $0.15L$ 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 $0.15L$ 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 *ILLC*. 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 athwart ships.

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.

$0.10L + 4$ (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 center line stiffener or by any other means.

2.2 Stern Frames

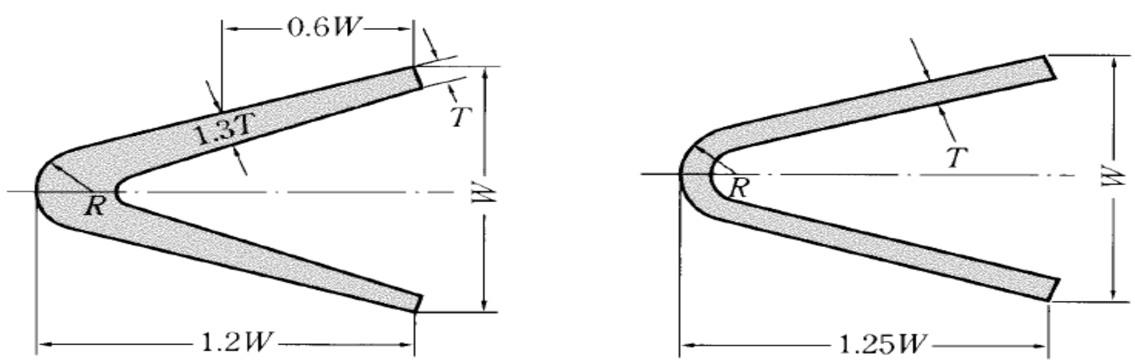
2.2.1 Application

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. 2.1. 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. 2.1 Standard Dimensions of Propeller Posts



$W: 2.2L + 88$ (mm)

$T: 0.18L + 15$ (mm)

$W: 2.5L + 100$ (mm)

$T: 2.2\sqrt{L} + 5.0$ (mm)

$R: 0.40L + 16\ (mm)$
Propeller Post of
Cast Steel Stern Frame

$R = 0.40L + 16\ (mm)$
Propeller Post of
Steel Stern Frame

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

$0.9L + 10\ (mm)$

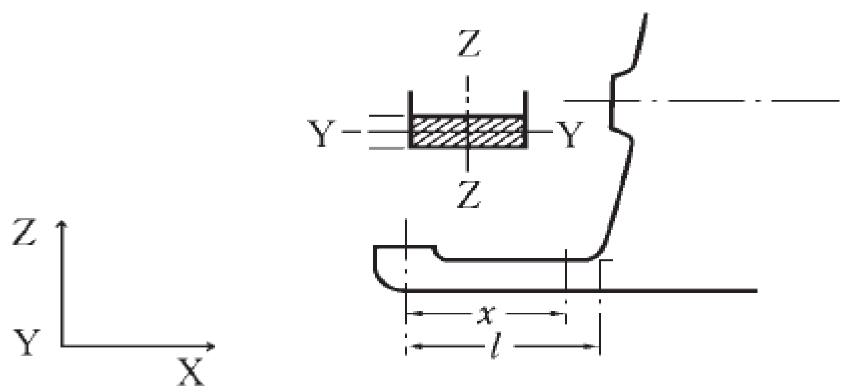
3. The propeller posts of cast steel stern frames and those of plate stern frames are to be provided with ribs at a suitable interval. Where the radius of curvature is large, a center line stiffener is to be provided.

4. For ships with relatively high speed for their length and ships exclusively engaging in towing purposes, 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. 2.2**) 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.

Fig. 2.2 Shoe piece



(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. 2.2** *l*: Distance (*m*) from the mid-point of the pintle bearing to the fixed point of the shoe piece, as specified in **Fig. 2.2**

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:

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

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)**

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.

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

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

Chapter 3 RUDDERS

3.1 General

3.1.1 Application

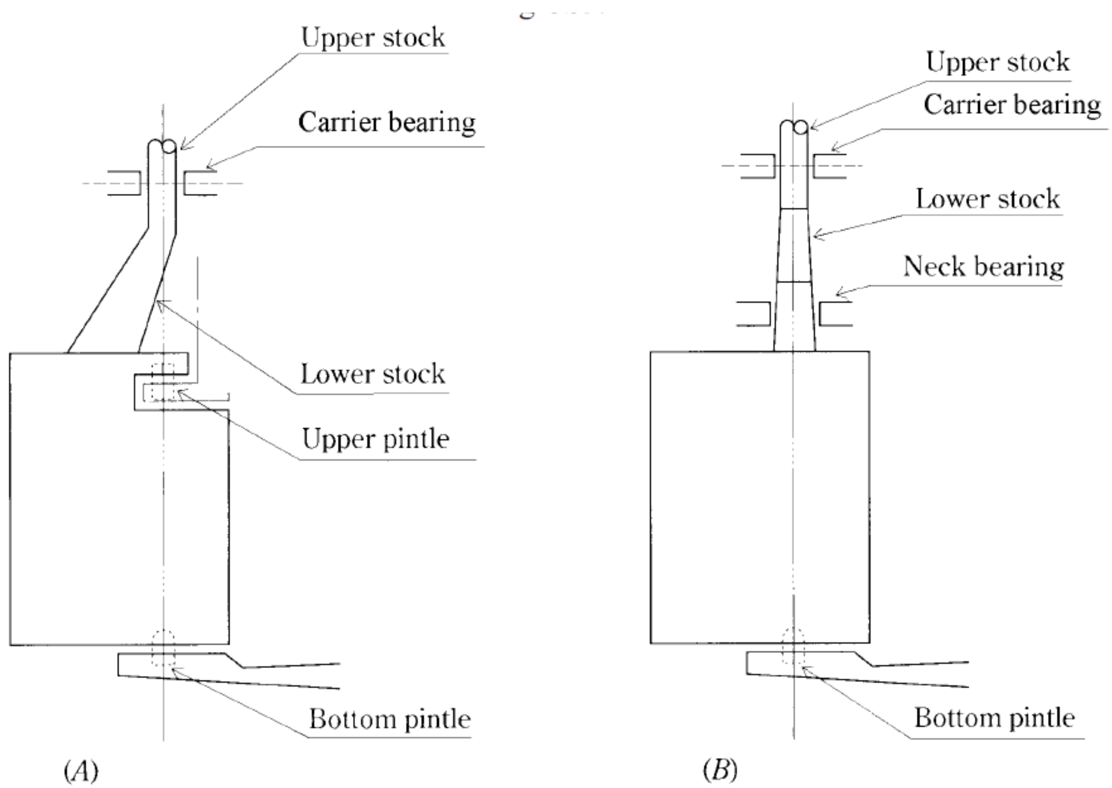
1. The requirements in this Chapter apply to double plate rudders of stream line section and ordinary shape, being divided into the following types, and single plate rudders.

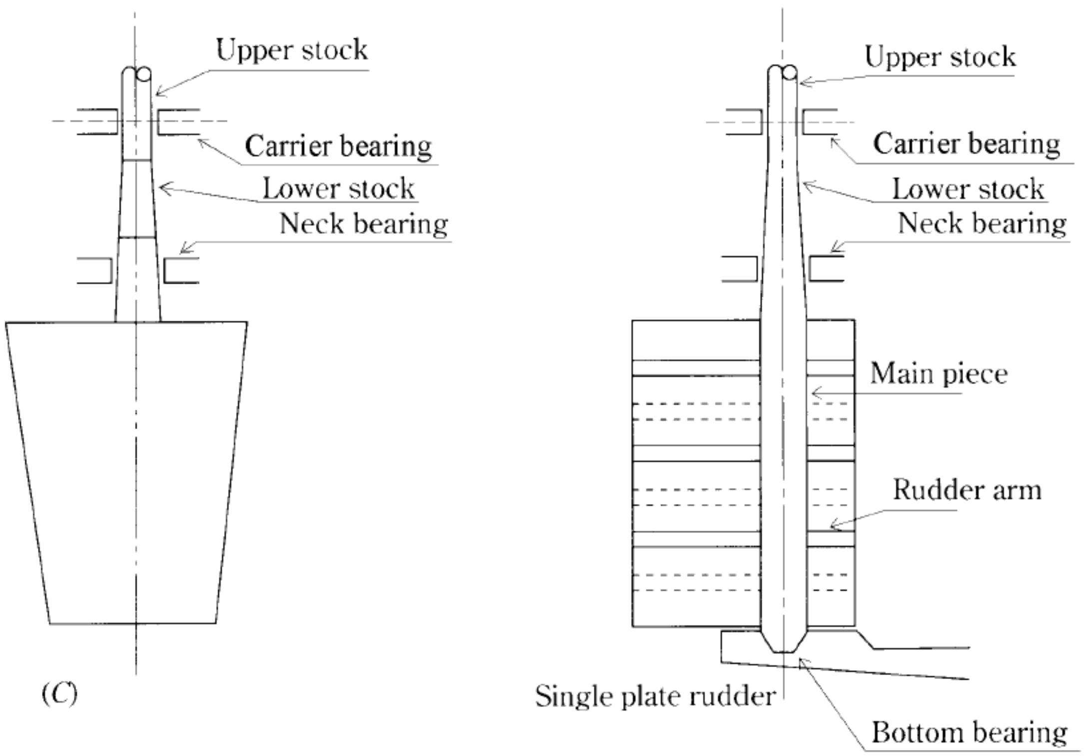
(1) Type *A*: Rudders with upper and bottom pintles (See **Fig. 3.1** (***A***))

(2) Type *B*: Rudders with neck bearing and bottom pintle (See **Fig. 3.1** (***B***))

(3) Type *C*: Rudders having no bearing below the neck bearing (See **Fig. 3.1** (***C***))

Fig 3.1





2. 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.

3. 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. 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 10**. For rudder stocks, pintles, coupling bolts, keys, and edge bars, the minimum yield stress is not to be less than 200 N/mm^2. The requirements in this Chapter are for materials with a yield stress of 235 N/mm^2. If materials having a 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: Yield stress (N/mm^2) of material used, and is not to be taken as greater than $0.7\sigma_B$ or 450 N/mm^2, whichever is the smaller

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

2. When the rudder stock diameter is reduced because of using steels with a 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. 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 10**. 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).**

3.1.3 Increase in Diameter of Rudder Stock for Special Cases

1. The diameter of rudder stocks of ships exclusively engaged in towing service is not to be less than **1.1** times those required in this Chapter.

2. 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.

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

3.1.4 Sleeves and bushes

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

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 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.

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

Where:

Λ: As obtained from the following formula

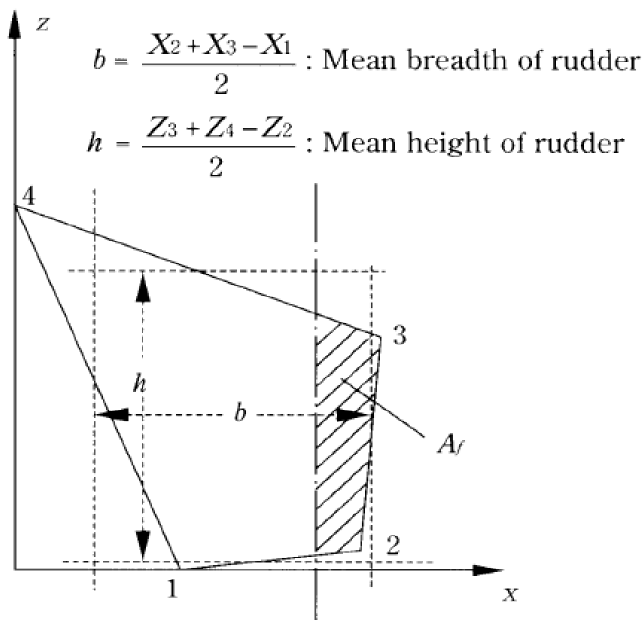
However, Λ is not required to be greater than 2.

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

Where:

h: Mean height of rudder (m), which is determined according to the coordinate system in **Fig. 3.2**

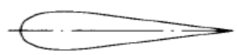
Fig. 3.2 Coordinate system of rudders



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 3.1**)

Table 3.1 Factor K_2

Profile type	K_2	
	Ahead conditions	Artern Condition
NACA-00 Göttingen-profiles 	1.1	0.80
Hollow profiles 	1.35	0.90
Flat side profiles 	1.1	0.90

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

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.

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

Where:

F_R: As specified in **3.2**

r: Distance (*m*) from the center of the rudder force on the rudder to the centerline 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.

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

Where:

b: Mean breadth *(m)* of rudder determined by the coordinate system in **Fig. 3.2**

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 centerline 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:

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

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

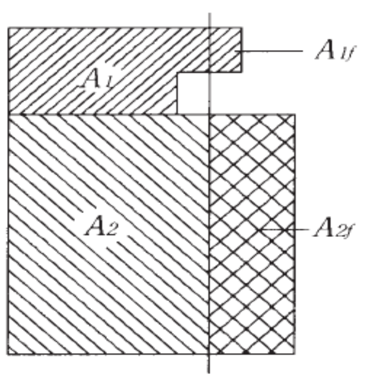
$$T_{Rmin} = 0.1F_R \frac{A_1 b_1 + A_2 b_2}{A} \qquad (N-m)$$

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_2include A_{1f} and A_{2f} respectively), as specified in Fig. 3.3

Fig. 3.3 Division of rudder



b_1 and b_2 : Mean breadth (m) of portions A_1 and A_2 respectively determined by applying Fig. 3.2

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.

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

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

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

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

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

r_1 and r_2, the distances from each center of rudder force of portions A_1 and A_2 to the centerline 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

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:

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

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

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

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**

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:

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

Where:

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

K_{p1}: Material factor for rudder plate as given in **3.1.2**

β: To be obtained from the following formula:

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

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

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:

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

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 centerline 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 centerline 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.

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

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

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

In the case of a Type *A* rudder, however, the section modulus and the web area of a horizontal section of the main piece in way of cut-outs are to be determined so that bending stress, shear stress and equivalent stress should not exceed the following stresses, respectively.

Bending stress: $\sigma_b = \frac{75}{K_m} (N/mm^2)$

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

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

Where:

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

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

5. The maintenance openings and the rudder plate cut-out of Type *A* rudders 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 Rudder Plates, Rudder Arms and Rudder Main Pieces of Single Plate Rudders

3.7.1 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_{p1}: Material factor for rudder plate as given in **3.1.2**

3.7.2 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.

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

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 **3.7.1**

3.7.3 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.

3.8 Couplings between Rudder Stocks and Main Pieces

3.8.1 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 center 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**

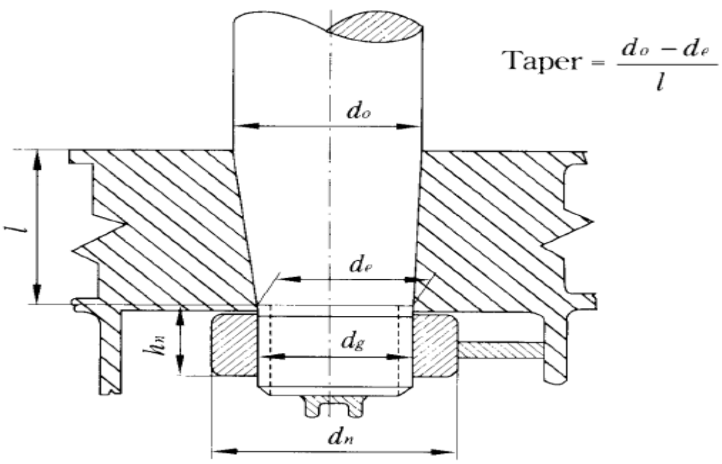
d_b: Bolt diameter (mm), determined by a number of bolts not exceeding 8

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

3.8.2 Cone couplings

1. Cone couplings that are mounted or dismounted without hydraulic arrangements (e.g. oil injection and hydraulic nut) are to be tapered $1:8{\sim}1:12$ of the diameter. (See **Fig. 3.4**)

Fig. 3.4 Cone coupling



The taper length *l* of rudder stocks fitted into the rudder plate and secured by the slugging nut is generally not to be less than 1.5 *times* the rudder stock diameter d_0 at the top of the rudder. In this case, for couplings between stock and rudder, a key is to be provided. The scantling of the key is to be to the discretion of the Society.

2. The dimensions of the slugging nut as specified in **-1** are to be as follows (See **Fig. 3.4**):

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

Length of nut: $h_n \geq 0.6d_g(mm)$

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

3. Cone couplings that are mounted or dismounted with hydraulic arrangements (e.g. oil injection and hydraulic nut) are to have a taper on the diameter of 1:12 ~ 1:20 (See **Fig. 3.4**).

The push-up force and the push-up length are to be to the discretion of the Society.

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

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

3.8.3 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.

$$d_b = \frac{0.18d}{\sqrt{n}}\sqrt{\frac{K_b}{K_S}}\ (mm)$$

Where:

d: Stock diameter *(mm)*, the greater of the diameters d_u or d_1 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 centerline 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 outside the bolt holes is not to be less than $0.67d_b\ (mm)$.

3.9 Pintles

3.9.1 Diameter of Pintles

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

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

Where:

B: Reaction force in bearing *(N)*

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

3.9.2 Construction of Pintles

1. 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. The minimum dimensions of the threads and the nuts of pintles are to be determined by applying the requirements in **3.8.2-2** correspondingly.

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

4. Pintles are to be properly protected from corrosion.

3.10 Bearings of Rudder Stocks and Pintles

3.10.1 Minimum Bearing Surface

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

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

Where:

B: As specified in **3.9**

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

The allowable surface pressure for the various bearing combinations is to be taken from **Table 3.2**. When verified by tests, however, values different from those in this Table may be taken.

Table 3.2 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 between 60 and 70 ,Shore *D* (Note 1)	5.5
Steel (Note 2) ,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%, according to a recognized standard. Synthetic bearings are to be of the type as deemed appropriate by the Society.

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

3.10.2 Length of Bearings

The length/diameter ratio of the bearing surface is not to be less than 1.0. However, the ratio is not to be greater than 1.2 unless specially approved by the Society.

3.10.3 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 in no way to be taken as less than 1.5 *mm* on the bearing diameter.

3.11 Rudder Accessories

3.11.1 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.

3.11.2 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 *IGC and IBC Codes IMO* 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 draught which corresponds to the summer draught assigned to the ship in accordance with the requirements of *ILLC*.

(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 meters of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

(7) "Mid-length" is the midpoint of L_s.

(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 forward and aft terminals respectively, 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 meters from keel line to the water line in question at the midpoint of L_s.

(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 4.1-1 and Table 4.1-2 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 4.1-1 and Table 4.1-2 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) "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 4.1-1 Permeability of general compartment

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

Table 4.1-2 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) calculated for the draughts d_s, d_p and dl 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) Level trim is to be used for the deepest subdivision draught and the partial subdivision draught. The actual service trim is to be used for the light service draught. Where any service condition, the trim variation in comparison with the calculated trim is greater than $0.005L_s$, one or more additional calculations of A are to be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation will be less than $0.005L_s$.

(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 centerline 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 ships centerline, all damage which extend from the outmost compartment (hereinafter referred to as wing compartment) to the ships centerline 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 favorable result.

(6) When determining the positive righting lever (*GZ*) of the residual stability curve, the displacement for the intact condition is to be used.

4.2.2 Compartment Flooding Probability (p_i)

1. The Compartment Flooding Probability (*pi*) 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:

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

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 centerline at the deepest subdivision load line between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor pi 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 loadline 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 aft most 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 center 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:

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

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

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

$$-p(x1_{j+1}, x2_{j+n-1}) \cdot \left[r\left(x1_{j+1}, x2_{j+n-1}, b_k\right) - r\left(x1_{j+1}, x2_{j+n-1}, b_{k-1}\right)\right]$$
$$+p(x1_{j+1}, x2_{j+n-2}) \cdot \left[r\left(x1_{j+1}, x2_{j+n-2}, b_k\right) - r\left(x1_{j+1}, x2_{j+n-2}, b_{k-1}\right)\right]$$

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 $J \leq J_k$:

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

In case $J > J_k$:

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

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 $J > J_k$:

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

$x1, x2, p1, p2, J$ and J_k are specified in $(\mathbf{1})$ 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:

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

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:

$S_i = min\{S_{final,i}\}$

$S_{final,i}$: It is the probability to survive in the final equilibrium stage of flooding.

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

K: Coefficient given by the following:

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

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

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

Where, θ_{min} is 25° and θ_{max} is 30° for cargo ships.

GZ_{max}: It is the maximum positive righting lever (m) up to the angle θ_v, However, in the calculations of $S_{final,i}$, It is not to be taken as more than 0.12m.

θ_v : It is the angle (°), in 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: It is the 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 $S_{final,i}$, it is not to be taken as more than 16 °.

θ_e: It is the equilibrium heel angle (°) in any stage of flooding.

2. 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 $x1_{(j)} \ldots . x2_{(j+n-1)}$ 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 $x1_{(j)} \ldots . x2_{(j+n-1)}$ 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:

$v(H, d^{'}) = 0.8\frac{(H-d^{'})}{7.8}$ if $H_m - d^{'} \le 7.8m$

$v(H,d^{'})=0.8+0.2\left[\frac{(H\text{-}d^{'}\text{-}7.8)}{4.7}\right]$ 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 $x1_{(j)} \ldots x2_{(j+n-1)}$, 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.

3. Where the requirement in **-3** above is applied, in general, each contribution dA to the Attained Subdivision Index A is obtained from the formula:

$$dA = p_i \cdot [v_1 \cdot s_{min1} + (v_2 - v_1) \cdot s_{min2} + \cdots + (1 - v_{m-1}) \cdot s_{\min m}]$$

v_m: The value calculated in accordance with **-3** 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.

4. In all cases, probability of survival (s_i) is to be taken as 0 in those cases where, taking into account sinkage, heel and trim, the openings in accordance with following **(1)** and **(2)** immerse at the final waterline:

(1) The openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of probability of survival (s_i)

(2) Air-pipes, ventilators and the openings which are closed by means of weathertight doors or hatch covers

5. 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 bulkhead 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 bulkhead deck become inaccessible or inoperable

(3) Immersion of piping or ventilation ducts maintained a watertight and located within any compartment.

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 showing whether the doors are open or closed at all operating positions

(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 the requirements of **-1** above are to be permanently closed at sea, and 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. 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 affixed at their operating positions stating “To be kept closed at sea”. However, such notices are not required for cargo hatch covers, fixed side scuttles and bolted manholes.

(4) Closing appliances for openings in the shell plating below the bulkhead deck accessible during the voyage are to be fitted with a device which prevents unauthorized opening, 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 normally closed at sea, and are to comply with the following **(1)** to **(4).**

(1) Closing appliances other than those permanently closed at sea are to be 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.

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

(3) Closing appliances are to be provided with a notice affixed at their operating positions stating “To be kept closed at sea”. Closing appliances permanently closed at sea are to be provided with a notice stating “Not to be opened at sea”. However, such notices are not required for fixed side scuttles.

(4) 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 center girder composed of web plates and face plates, and the center 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 2.5*m* between the center 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.

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

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 $0.5d_0$. (See **Fig.5.1**) Where frame brackets are provided, the depth of floors at the inner edge of brackets may be $0.5d_0$.

3. In ships having an unusually large rise of floor, the depth of floor plates at the center 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 center line: $0.0625l(m)$

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

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

Where:

S: Spacing (*m*) of floors

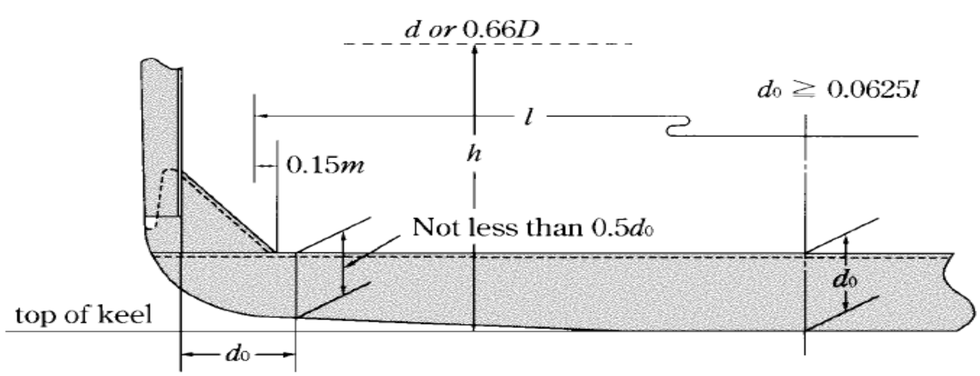
h : *d* (*m*) or 0.66*D* (*m*), whichever is the greater

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. 5.1**)

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

Fig. 5.1 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 center 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 center 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 center 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 $d + 0.026L$ 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 ships 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 **1.2.47, Part 1A**.

$$h = B^{'}/20$$

$B^{'}$: 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 less than 500 *gross tonnage*; ships not engaged in international voyages; or ships that are deemed by the Society to not require a double bottom due to factors such as structural configuration, hull form, or purpose.

3. Double bottoms may be omitted in way of watertight tanks, including dry tanks of moderate size subject to 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 cannot 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. With the exception of the after tunnel well, where bilge wells are provided for water drainage, such wells are not to extend for more than one-half the depth of the double bottom nor are they to come within 460 *mm* of the bottom shell.

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.

6.1.7 Wells

1. Small wells constructed in the double bottom in connection with drainage arrangements of holds are not to extend downward more than necessary. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel.

2. 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.

3. For wells specified in **-1** and **-2** above except a well at the end of the shaft tunnel, the vertical distance from the bottom of such a well to a plane coinciding with the keel line specified in **1.2.47, Part 1A** is not to be less than 0.5 *m*.

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 0.5*L* 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 $0.25B$ 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 $0.75L$ amidships.

2. Lightening Holes may be provided on centre girders in alternate frame spaces for $0.75L$ 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:

$0.05L + 6 \quad (mm)$

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 *meters* connecting the center girder plates to the bottom shell plating as well as the adjacent bottom longitudinals. Where the spacing of these brackets exceeds 1.25 *meters*, additional stiffeners are to be provided on the center 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.

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

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 $0.08d_0$, where d_0 is the depth of the center girder in meters.

6.3 Side Girders

6.3.1 Arrangement

1. Side girders in $0.5L$ amidships are to be so arranged that the distance from the center 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*.

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

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 $0.08d_0$ (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 *meters*.

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

(1) 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: $0.6\sqrt{L} \pm 2.5 \quad (mm)$

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

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 $0.08d_0$, 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 center 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. 6.1)

S: Spacing (*m*) of frames

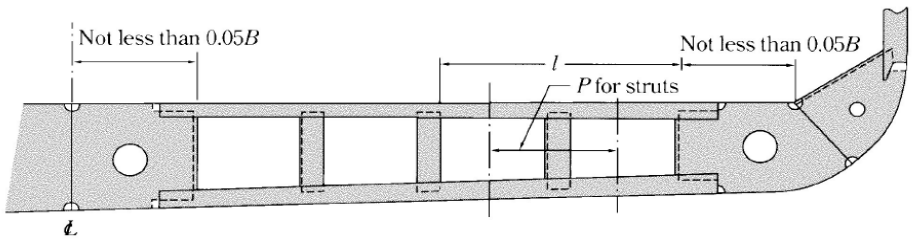
h: *d + 0.026L (m)*

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. 6.1 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 center 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:

$CShl^2 (cm^3)$

Where:

l : Spacing (*m*) of solid floors

S : Spacing (*m*) of longitudinal

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

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

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

4.1 for elsewhere

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

$2.2SPh \quad (cm^2)$

Where:

S : Spacing (*m*) of longitudinals

P : Breadth (*m*) of the area supported by the strut (See **Fig. 6.1**)

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 longitudinal 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 $0.037L$ 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 ships 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 6.1** is defined as the strengthened bottom forward.

Table 6.1 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 tan 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	0.3L

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 0.05L abaft the after end of the strengthened bottom forward, full or half-height girders are to be provided in accordance with **Table 6.2**. Where transverse framing is adopted between the collision bulkhead and 0.025L abaft the after end of the strengthened bottom forward, half height girders or shell stiffeners are to be provided in accordance with **Table 6.2**.

2. Between the collision bulkhead and the after end of the strengthened bottom forward, solid floors are to be provided in accordance with **Table 6.2**.

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 0.025L but less than 0.037L 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 6.2 Construction of Strengthened Bottom Forward

<table>
<tr><td colspan="2">Side / Members
Double B</td><td>Side Girders</td><td>Half-height Girders or Shell Stiffeners</td><td>Solid Floors</td></tr>
<tr><td rowspan="2">Transverse framing</td><td>Transverse framing</td><td rowspan="2">To be provided at intervals withim 2.5 meters</td><td rowspan="2">To be provided between side girders</td><td>To be provided at every frame</td></tr>
<tr><td>Longitudinal framing</td><td>To be provided at intervals withim 2.5 meters</td></tr>
<tr><td rowspan="2">Longitudinal framing</td><td>Transverse framing</td><td rowspan="2">To be provided at intervals within 2.5 meters</td><td rowspan="2">–</td><td>To be provided at intervals within 2.5 meters</td></tr>
<tr><td>Longitudinal framing</td><td></td></tr>
</table>

6.9.4 Scantlings of Longitudinal Shell Stiffeners or Bottom Longitudinals

1. 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: $0.774\, l$

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 6.3**

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

Table 6.3 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

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: $0.667\frac{V}{\sqrt{L}} - 0.267$

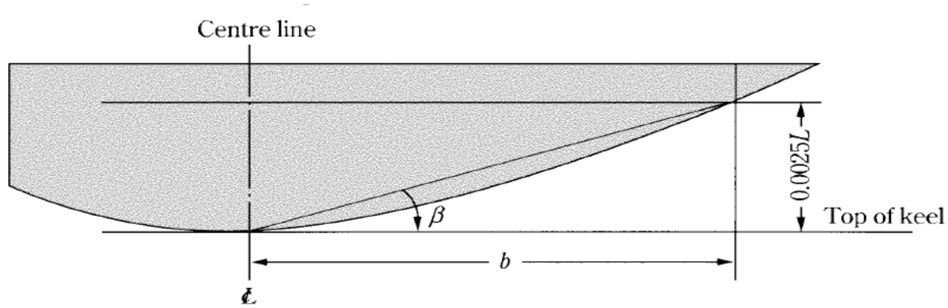
Where $\frac{V}{\sqrt{L}}$ is 1.3 and over: $1.5\frac{V}{\sqrt{L}} - 1.35$

B: Slope of the ships bottom obtained from the following formula, but C_2/β need not be taken as greater than 11.43 (See **Fig. 6.2**)

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

b : Horizontal distance (*m*) measured at 0.2*L* from the stem, from the center 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.6.2**)

Fig. 6.2 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 $0.2L$ 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.

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

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 $0.15L$ from the fore end and the after peak bulkhead: 2.6

For frames between $0.15L$ 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:

$$2.4n\left[0.17 + \frac{1}{9.81}\frac{h_1}{h}\left(\frac{l_1}{l}\right)^2 - 0.1\frac{l}{h}\right]Shl^2 \quad (cm^3)$$

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 center 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: $C_1 Shl^2 (cm^3)$

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 7.1**

Table 7.1 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 7.2**

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 7.2 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.

$$8Shl^2 (cm^3)$$

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 $0.12L$ 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 $0.05D$ and $0.15D$ from the top of the keel) and 50% (below $0.05D$ from the top of the keel).

$$8Shl^2 (cm^3)$$

Where:

S and l : As specified in **7.4.1**

h : Vertical distance (m) from the longitudinals to a point $0.12L$ above the top of the keel, but is not to be less than $0.06L$ (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:

$$8Shl^2 (cm^3)$$

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 $\{d + 0.044L - 0.54\}$ above the top of the keel.

Chapter 8 CANTILEVER BEAM CONSTRUCTION

8.1 Cantilever Beams

8.1.1 Construction and Scantlings

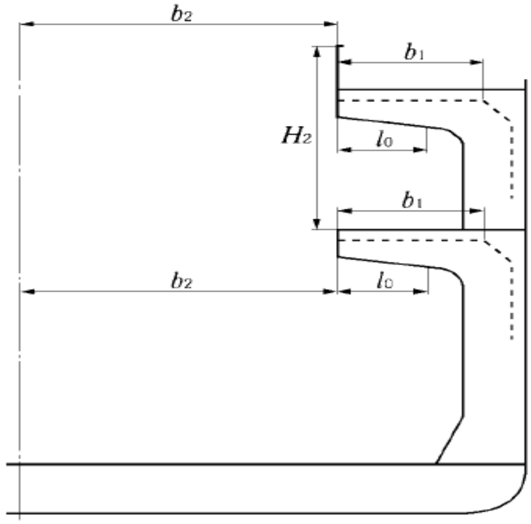
Cantilever beams are to comply with the requirements in **(1)** to **(7):**

(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. 8.1)

Fig. 8.1 Measurement of l_0, b_1, b_2, and H_2



The loading height of cargo, H_2, shown in the figure, is to be taken into consideration when h_2 of the lower deck is assumed.

$$7.1Sl_0\left(\frac{1}{2}b_1h_1 + b_2h_2\right)(cm^3)$$

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:

$$t_1 = 0.0095 \frac{S\left(\frac{1}{2}b_1 h_1 + b_2 h_2\right)}{d_c}$$

$$t_c = 7.5d_c + 0.46t_1 + 1.5(mm)$$

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 *meters* 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 hach covers on lower decks are to comply with 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 provide 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 members supporting hatch covers on lower decks.

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%.

$$7.1Sl_1\left(\frac{1}{2}b_1h_1 + b_2h_2\right)(cm^3)$$

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:

$$7.1C_1Sl_1\left(\frac{1}{2}b_1h_1 + b_2h_2\right)(cm^3)$$

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:

$$0.15 + 0.5\frac{\frac{1}{2}b_1'h_1' + b_2'h_2'}{\frac{1}{2}b_1h_1 + b_2h_2}$$

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:

$$t_1 = 0.0095\frac{C_2S\left(\frac{1}{2}b_1h_1 + b_2h_2\right)}{d_w}\frac{l_1}{l} + 2.5\ (mm)$$

$$t_2 = 7.5d_w + 0.46t_1 + 1.5(mm)$$

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:

$$0.6 + 9.81\frac{0.05hl^2 + 0.09h_u l_u^2}{1.4\left(\frac{1}{2}b_1 h_1 + b_2 h_2\right) l_1}$$

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 $d + 0.038L$ 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 *3m*, 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 formula.

Sectional area of panting beams: $0.1L + 5 \quad (cm^2)$

Thickness of steel plates: $0.02L + 5.5 \quad (mm)$

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: $8Shl^2(cm^3)$

Web thickness: $0.02L + 6.5(mm)$

where:

S : Breadth (m) of area supported by the side stringer.

h : Vertical distance (m) from the center of S to a point of $0.12L$ (m) above the top of keel However, where h is less than that $0.06L(m)$, h is to be taken as $0.06L(m)$.

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: $5.3L + 250(mm)$

Thickness: $0.02L + 6.5(mm)$

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: $0.2l(m)$ or $0.0085L + 0.18(m)$ whichever is greater.

Section modulus: $1.2Sl^2(cm^3)$

Web thickness: $0.005\frac{SLl}{d_1} + 2.5 \quad (mm)$ or $4 + 0.6\sqrt{L} \quad (mm)$, 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 center 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: $0.2l_0\ (m)$, $0.0053l + 0.25\ (m)$ or 2.5 *times* the depth of slots for longitudinals (m), whichever is the greatest.

Section modulus: $8Shl_0^2\ (cm^3)$

Web thickness: $0.042\frac{Shl_0}{d_1} + 2.5$ (mm) or $0.02L + 6.5$ (mm), whichever is greater.

where:

S : Spacing (m) of transverses.

d_1 : As specified in **-1**.

h : Vertical distance (m) from the center of l_0 to a point of $0.12L$ (m) above the top of keel However, where h is less than that $0.06L(m)$, h is to be taken as $0.06L(m)$.

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: $0.2l_1(m)$ or $0.0053L + 0.25\ (m)$ whichever is greater.

Section modulus: $4Shl_0l_1(cm^3)$

Web thickness: $0.031\frac{Shl_1}{d_1} + 2.5$ (mm) or $0.02L + 6.5(mm)$, whichever is greater.

where:

S : Breadth (m) of area supported by the stringer.

h : Vertical distance (m) from the center of S to a point of $0.12L$ (m) above the top of keel However, where h is less than that $0.06L(m)$, h is to be taken as $0.06L$ (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 center of b to a point of $0.12L$ (m) above the top of keel However, where h is less than that $0.06L(m)$, h is to be taken as 0.06L (m).

l : Length (m) of cross ties.

k: $\sqrt{\dfrac{I}{A}}$

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:

$$1.14 S h l^2 (cm^3)$$

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.

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 cannot 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

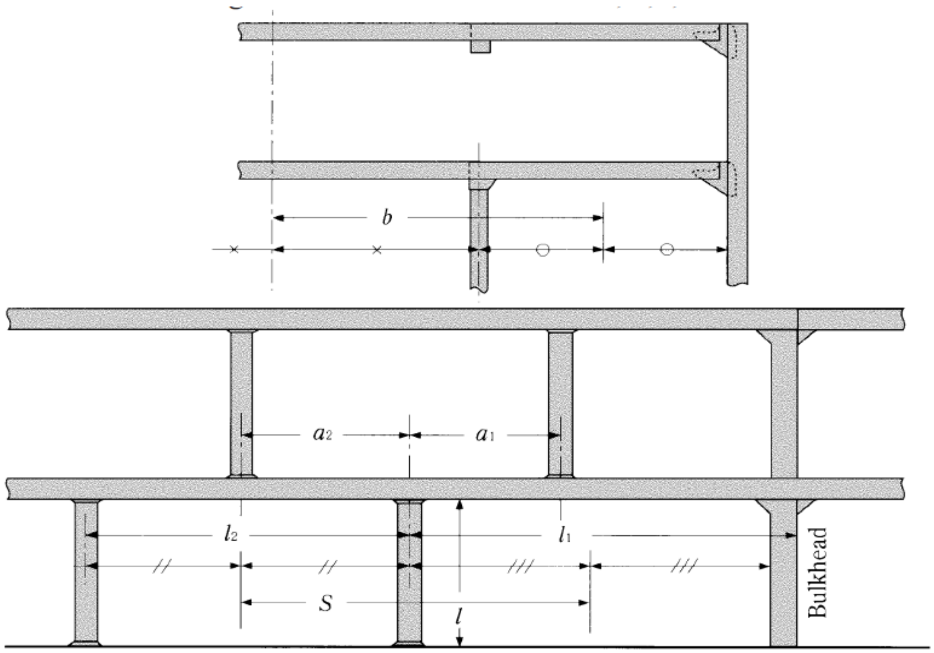
The sectional area of pillars is not to be less than that obtained from the following formula:

$$\frac{0.223w}{2.72-\frac{l}{k_0}} \qquad (cm^2)$$

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. 11.1**)

Fig. 11.1 Measurement of *S*, *b*, *l*, etc.



$$k_0 = \sqrt{\frac{I}{A}}$$

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**

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:

$$K_{w0} + Sbh\ (kN)$$

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.11.1**)

b : Mean distance (m) between the mid-points of two adjacent spans of beams supported by the pillars or the beam brackets. (See **Fig.11.1**)

h : Deck load (kN/m^2) specified in **17.1** for the deck under consideration

wo: 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.11.1**)

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 *kwo* 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 asin **-1** and -**2**.

4. The load supported by pillars of decks carrying cargoes which cannot 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 (wo).

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:

$$0.22d_p + 4.6 \quad (mm)$$

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:

$$1.09Sbh \quad (cm^2)$$

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 *meters* above the top of the overlow 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 *meters* 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 *meters* 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:

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

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:

$$1.29l(lbh + kw) \quad (cm^3)$$

Where:

l : Distance (*m*) between the centers of pillars or from the center 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. 12.1**)

b : Distance (*m*) between the centers of two adjacent spans of beams supported by girders or frames (See **Fig. 12.1**)

h : Deck load (kN/m^2) specified in **17.1**

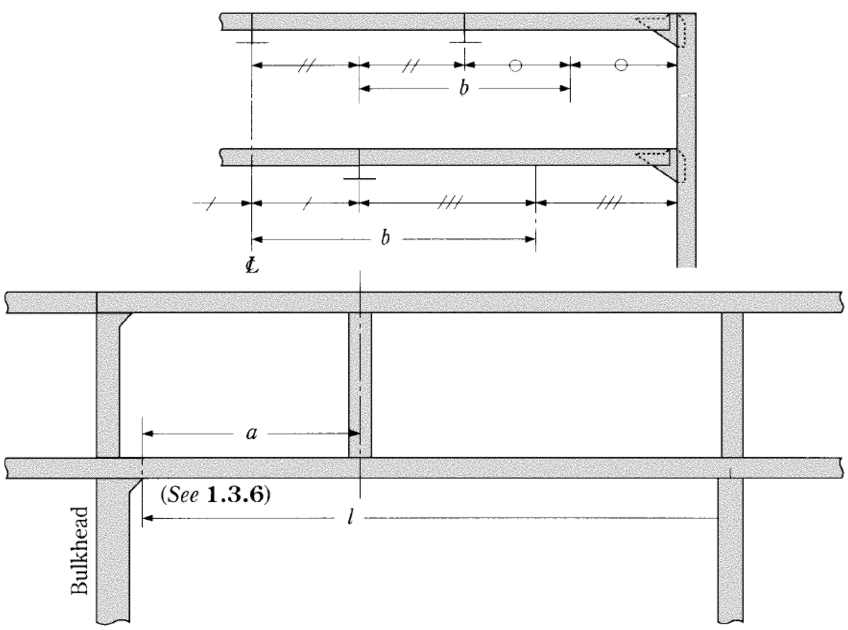
w : Deck load (*kN*) supported by the tween deck pillar as specified in **11.2**

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. 12.1**)

$$12\frac{a}{l}\left(1 - \frac{a}{l}\right)^2$$

Fig. 12.1 Measurement of *l*, *a* and *b*



(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.

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 under any circumstances:

$$0.484l(lbh + kw) \quad (cm^3)$$

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 cannot 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 following formulae:

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:

$$10s_1 + 2.5 \quad (mm)$$

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 $0.2l$ 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 1mm 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 centers of pillars or from the center of the pillar to the inner edge of the beam bracket

b : Distance (m) between the centers of two adjacent girders or from the center 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 cannot 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.

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 0.05L_f , from the forward terminal of the length for freeboard, but not more than 0.08L_f or 0.05L_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 0.015L_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 bulkhead 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 bulkhead deck, the part of the ramp which is more than 2.3 *m* above the bulkhead 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.

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 13.1**.

Table 13.1 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 ships 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 superstructure deck and to be made weathertight. However, where the extension is 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 *meters*, 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:

$$3.2\sqrt{h} + 2.5 \quad (mm)$$

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 center line of ship. It is not to be less than 3.4 *meters*.

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:

$$2.8CShl^2 (cm^3)$$

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 center line of the ship.

Where the vertical distance is less than 6.0 *meters*, h is to be taken as 1.2 *meters* greater than 0.8 *times* the vertical distance.

C : Coefficient given in **Table 13.2**, according to the type of end connection.

Table 13.2 Value of *C*

<table>
<tr><td colspan="7">Vertical stiffener</td></tr>
<tr><td rowspan="3" colspan="2">Lower end</td><td colspan="5">Upper end</td></tr>
<tr><td rowspan="2" colspan="2">Lug-connection of supported by horizontal girders</td><td colspan="2">Connection</td><td rowspan="2">End of stiffener unattached</td></tr>
<tr><td>Type A</td><td>Type B</td></tr>
<tr><td colspan="2">Lug-connection or supported by horizontal girders</td><td colspan="2">1.00</td><td>1.00</td><td>1.15</td><td>1.35</td></tr>
<tr><td colspan="2">Bracketed</td><td colspan="2">0.80</td><td>0.80</td><td>0.90</td><td>1.00</td></tr>
<tr><td colspan="2">Only the web of stiffener attached at end</td><td colspan="2">1.15</td><td>1.15</td><td>1.35</td><td>1.60</td></tr>
<tr><td colspan="2">End of stiffener unattached</td><td colspan="2">1.35</td><td>1.35</td><td>1.60</td><td>2.0</td></tr>
<tr><td colspan="7">Horizontal Stiffener</td></tr>
<tr><td rowspan="2">The other end</td><td colspan="6">One end</td></tr>
<tr><td colspan="2">Lug-connection, bracketed or supported by vertical girders</td><td colspan="4">End of stiffener unattached</td></tr>
<tr><td>Lug-connection, bracketed or supported by vertical girders</td><td colspan="2">1.00</td><td colspan="4">1.35</td></tr>
<tr><td>End of stiffener unattached</td><td colspan="2">1.35</td><td colspan="4">2.00</td></tr>
</table>

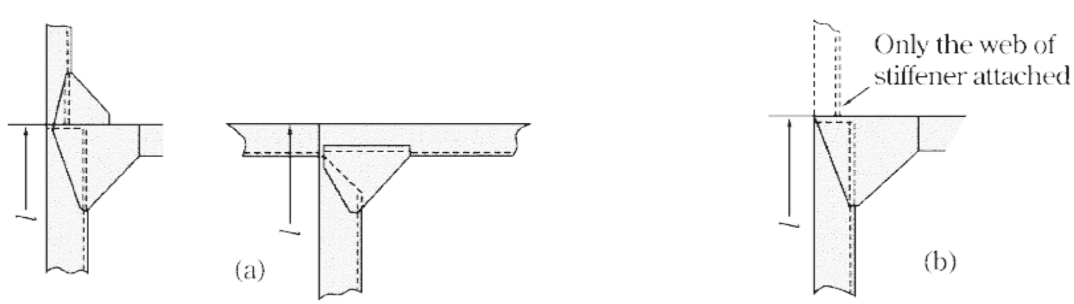
Notes:

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. 13.1** **(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. 13.1** **(b)).**

Fig. 13.1 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 center line of the ship Where the vertical distance is less than 6.0 meters, *h* is to be taken as 1.2 meters 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 *meters* 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 Plaring

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

Construction of corrugated bulkheads is to be in accordance with the requirements given in 12.2.4, Part 2.

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 ships 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 the requirements of **-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.

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

1. 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.

2. For watertight doors which are to be capable of being remotely closed, an indication is to be placed locally showing that the door is in remote control mode.

13.3.6 Alarms

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.

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 8.**

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 quick acting or 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

For the application of this chapter, trunks required to maintain watertightness are to be capable of withstanding internal or external pressure under the most severe conditions at the intermediate or final stages of flooding.

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*, 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:

$$3.6S\sqrt{h} + 3.5 \ \ (mm)$$

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 *meters* 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:

$$7CShl^2(cm^3)$$

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 *meters* above the top of overflow pipes

C: Coefficient given in **Table 14.1**, according to the type of end connections.

Table 14.1 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 double bottoms or to a stiffener of equivalent strength attached to the face of adjacent members, or a connection of equivalent strength (See Fig 13.1 **(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 13.1 **(b))**

14.2.4 Girders supporting Bulkhead Stiffeners

1. The section modulus of girders is not to be less than obtained from the following formula:

$$7.13Shl^2(cm^3)$$

Where:

S: Breadth (*m*) of the 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 de 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

Construction of corrugated bulkheads is to be in accordance with the requirements given in **12.2.4, Part 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 s Z_σ obtained from the following formula. However, application of the requirement may be dispensed with to ships not exceeding 60 meters in length at the discretion of the Society.

$$Z_\sigma = 5.72(M_s + M_w) \quad (cm^3)$$

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:

$0.11 C_1 C_2 L_1^2 B(C_b' + 0.7) \quad (kN - m)$ for sagging moment of M_s

$0.19 C_1 C_2 L_1^2 B C_b' \quad (kN - m)$ for hogging moment of M_s

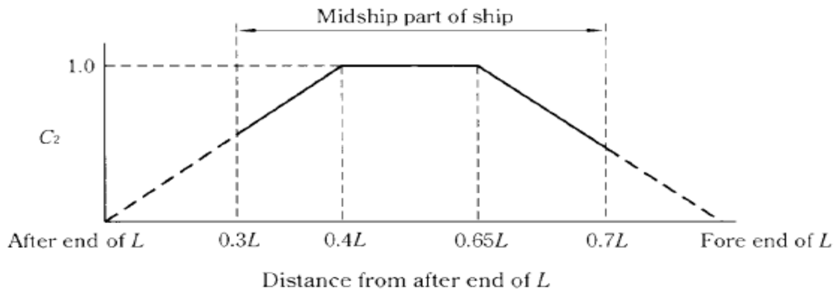
C_1: As given by the following formula: 0.03 L_1 + 5

L_1 : Length (*m*) of ship specified in **1.2.2, Part 1A** or 0.97 *times* the length of ship on the designed maximum load line, whichever is smaller

C_b' : Volume of displacement corresponding to the designed maximum load line divided by L_1Bd However, the value is to be taken as 0.6, where it is less than 0.6.

C_2: Coefficient specified along the length at positions where the transverse section of the hull is under consideration, as given in **Fig. 15.1**

Fig. 15.1 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:

$$W_{min} = C_1 L_1^2 B(C_b' + 0.7) \quad (cm^3)$$

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 *meters* in length and 1.2 *meters* in breadth need not be deducted, provided that the sum of their breadths in any single transverse section is

not more than $0.06(B - \sum b) \cdot \sum b$ is the sum of the openings exceeding 1.2 *meters* 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:

$$Y\left(0.9 + 0.2\frac{X}{B}\right)$$

Where:

X: Horizontal distance (*m*) from the top of continuous strength member to the center 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 bulkhead 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:

$$4.5L + 775 \quad (mm)$$

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:

$$0.044L + 5.6 \quad (mm)$$

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:

$$4.1S\sqrt{d + 0.04L} + 2.5 \quad (mm)$$

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:

$$4.7S\sqrt{d + 0.035L} + 2.5 \quad (mm)$$

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.

$$4.0S\sqrt{d + 0.035L} + 2.5 \quad (mm)$$

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.

$$5.6 + 0.044L \quad (mm)$$

16.4.2 Shell Plating for 0.3L from the Fore End

The thickness of shell plating for 0.3L from the fore end is not to be less than that obtained from the following formula:

$1.34S\sqrt{L} + 2.5 \quad (mm)$

Where:

S : Spacing (m) of longitudinal or transverse frames

16.4.3 Shell Plating for 0.3L from the After End

The thickness of shell plating for $0.3L$ 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:

$1.20S\sqrt{L} + 2.5 \quad (mm)$

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 ships length, special consideration is to be paid to the thickness of shell plating.

(1) In ships having a bow draught of not more than $0.025L$ 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 16.1**

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**

Table 16.1 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

(2) In ships having a bow draught of not less than $0.037L$ 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).**

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:

$$4.5 + 0.09L \quad (mm)$$

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 $0.25L$ abaft the fore end.

$$1.15S\sqrt{L} + 2.0 \quad (mm)$$

Elsewhere

$$0.94S\sqrt{L} + 2.0 \quad (mm)$$

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.

$$5.0 + 0.07L \quad (mm)$$

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:

$$a(0.067bL - y) \quad (kN/m^2)$$

Where:

a and b : As given by **Table 17.1** according to the position of decks.

However, where C_b is less than 0.7, value of *b* may be suitably modified.

Table 17.1 Values of *a* and *b*

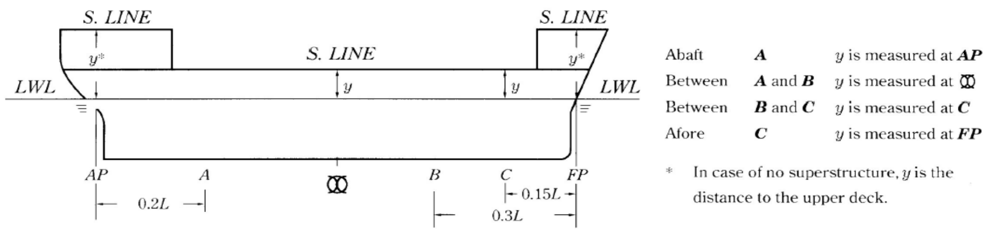
Column	Position of Deck	*a*				*b*
		Deck plating	Beams	Pillars	Deck Girders	
I	Forward of 0.15*L* abaft the fore end	14.7	9.80	4.90	7.35	1.42
II	Between o.15*L* and 0.3*L* abaft the fore end	11.8	7.85	3.90	5.90	1.20
III	Between o.3*L* abaft the fore end and 0.2*L* afore the aft end	6.90	4.60	2.25	2.25[1] 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. 17.1 Position of Measuring *y*



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. 17.1**)

(2) *h* for the deck given in Column II in **Table 17.1** 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 17.2**. However, where the *h* value calculated from the formula in **Table 17.2** 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.

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 17.2 Minimum Value of *h*

Column	Position of deck	*h*	*C*		
			Beams	Pillars, Longitudinal and transverse deck girders	Deck plating
I and II	Forward of 0.3*L* abaft the fore end	$C\sqrt{L+50}$	2.85	1.37	4.20
III	Between o.3*L* abaft the fore end and 0.2*L* afore the aft end		1.37	1.18	2.05
IV	Afterward of 0.2*L* afore the aft end	$C\sqrt{L}$	1.95	1.47	2.95
Second tier superstructure deck above the freeboard deck			1.28	0.69	1.95

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 the water influx to the compartments under the bulkhead deck on ro-ro spaces.

3. 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

Hatchways or other openings on strength or effective decks are to have well rounded corners, and compensation is to be suitably provided as necessary.

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 0.5L 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 0.15L 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 0.15L from Both Ends

Beyond 0.15L 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 0.05L 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

$$1.47S\sqrt{h} + 2.5 \quad (mm)$$

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

$$1.63S\sqrt{h} + 2.5 \quad (mm)$$

Where:

S : Spacing (m) of transverse beams

h : Deck load (kN/m^2) specified in **17.1**

(c) Elsewhere

$$1.25S\sqrt{h} + 2.5 \quad (mm)$$

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 cannot 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:

$$ac(0.067bL - y) \quad (m)$$

Where:

a: As given by the following formulae:

Exposed front bulkhead and wall of the first tier:

$$2.0 + \frac{L}{120}$$

Exposed front bulkhead and wall of the second tier:

$$1.0 + \frac{L}{120}$$

Exposed front bulkhead and wall of the third tier, and side walls and protected end bulkheads and front walls:

$$0.5 + \frac{L}{120}$$

Aft bulkheads and walls located abaft the midship:

$$0.7 + \frac{L}{1000} - 0.8\frac{x}{L}$$

Aft bulkheads and walls located afore the midship:

$$0.5 + \frac{L}{1000} - 0.4\frac{x}{L}$$

b : As given by the following formulae:

Where $\frac{x}{L}$ is less than 0.45:

$$1.0 + \left(0.5 - 1.1\frac{x}{L}\right)^2$$

Where $\frac{x}{L}$ is 0.45 and over:

$$1.0 + 1.5\left(1.1\frac{x}{L} - 0.5\right)^2$$

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 $0.15L$, the side wall is to be equally subdivided into span not exceeding $0.15L$ and the distance from the mid-point of the subdivisions to the after perpendicular is to be taken.

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.

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 18.1** irrespective of the provision in **-1**.

Table 18.1

	Exposed front bulkhead and Wall of the first tier	Others
L is 50 *meters* and under	3.0 (m)	1.5 (m)
L exceeds 50 *meters*	$2.5+\frac{L}{100}$ (m)	$1.25+\frac{L}{200}$ (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:

$$3S\sqrt{h} \quad (mm)$$

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 or 5 *mm*, whichever is greater, irrespective of the provisions in **-1**:

Bulkhead plating of the first tier:

$$5.0 + \frac{L}{100} \quad (mm)$$

Plating of other bulkheads:

$$4.0 + \frac{L}{100} \quad (mm)$$

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:

$$3.5Shl^2 \quad (cm^3)$$

Where:

S and *h*: As specified in **18.2.2**

l : Tween deck height (*m*)

However, where l is less than 2 *meters*, *l* is to be taken as 2 *meters*.

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.

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 $0.25L_f$ abaft the for end of L_f.

Position II: Upon exposed superstructure decks situated abaft of the point located $0.25L_f$ 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 $0.25L_f$ abaft the fore end of L_f and located at least two standard heights of superstructure above the freeboard deck.

19.1.3 Renewal Thickness for Ship in Operation

The structural drawings for hatch covers and hatch coamings complying with the requirements of **19.2** are to indicate the renewal thickness ($t_{renewal}$) for each structural element given by the following formula in addition to the as built thickness ($t_{as-built}$). If the thickness for voluntary addition is included in the as built thicknesses, the value may be at the discretion of the Society.

$$t_{renewal}=t_{as\text{-}built}-t_c+0.5 \quad (mm)$$

t_c: Corrosion additions specified in **Table 19.1**

Where corrosion addition t_c is 1.0 (mm) renewal thickness may be given by the formula:

$$t_{renewal}=t_{as\text{-}built}-t_c \quad (mm)$$

19.2 Hatchways

19.2.1 Application

1. The construction and the means for closing of cargo and other hatchways are to comply with the requirements in **19.2**.

2. Notwithstanding the provisions in this paragraph, the construction and means for closing of cargo and other hatchways of bulk carriers defined in **1.3.1(13), Part 1 B** and ships intended to be registered as” bulk carriers “are to be at the discretion of the Society.

3. 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.

19.2.2 General Requirement

1. Primary supporting members and secondary 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 secondary stiffeners is not to exceed 1/3 of the span of the primary supporting members.

3. Secondary stiffeners of hatch coamings are to be continuous 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 *tc* 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 19.1** 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”).

5. Strength calculations using beam theory, grillage analysis or *FEM* are to be performed with net scantlings.

Table 19.1 Corrosion Additions

<table>
<tr><th>Type of ship</th><th colspan="2">Type of structural member</th><th>Corrosion addition t_c (mm)</th></tr>
<tr><td rowspan="2">Container carriers and car carriers</td><td colspan="2">Steel hatch covers</td><td>1.0</td></tr>
<tr><td colspan="2">Hatchway coamings</td><td>1.5</td></tr>
<tr><td rowspan="4">Ships other than those specified above and subject to the application of this section</td><td colspan="2">Single plating type hatch cover</td><td>2.0</td></tr>
<tr><td rowspan="2">Double plating type hatch cover</td><td>Top, side and bottom plating</td><td>1.5</td></tr>
<tr><td>Internal structures</td><td>1.0</td></tr>
<tr><td colspan="2">Hatchway coamings</td><td>1.5</td></tr>
</table>

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 overs, portable beams and hatchway coamings applying the requirements in 19.2 are specified in following **(1)** to **(5)**:

(1) Design vertical wave load $P_V(kN/m^2)$ is not to be less than that obtained from **Table 19.2**. Design vertical wave loads need not to be combined with cargo loads according to **(3)** and **(4)** simultaneously.

Table 19.2 Design Vertical Wave Load $Pv^{(*1)(*2)}(kN/m^2)$

		$P_y(kN/m^2)$
Position I	For $0.25L_f$ forward	$\frac{9.81}{76}\left\{\left(4.28L_f+28\right)\frac{x}{L_f}-1.71L_f+95\right\}^{(*3)}$
	Elsewhere	$\frac{9.81}{76}(1.5L_f+116)$
Position II		$\frac{9.81}{76}(1.1L_f+87.6)$

Notes:

(*1) L_f : length of ship for freeboard defined in 1.2.3, Part 1A (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_V may be taken as $\frac{9.81}{76}\left(1.5L_f+116\right)$ (kN/m^2)

(2) Design horizontal wave load $P_H(kN/m^2)$ is not to be less than that obtained from the following formulae.

However, P_H is not to be taken less than the minimum values given in Table 19.3.

$P_H = ac\,(bC_1 - y)$

a: 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: Length of ship specified in **1.2.2, Part 1A** (m). However, L_1 need not to be greater than 97% of the total length on the summer load waterline

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

b: As given by the following formulae:

$$1.0 + \left(\frac{0.45 - \frac{x}{L_1}}{C_{b1} + 0.2}\right)^2 \quad \text{for } \frac{x}{L_1} < 0.45$$

$$1.0 + 1.5\left(\frac{\frac{x}{L_1} - 0.45}{C_{b1} + 0.2}\right)^2 \text{ for } \frac{x}{L_1} \geq 0.45$$

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 $0.15l_1$, the side hatchway coaming or hatch cover skirt plates are to be equally subdivided into spans 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. 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.

c: As given by the following formula. However, where $\frac{b'}{B'}$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.

Tabla 19.3 Minimum Value of P_H (kN/m^2)

Unprotected front coamings and hatch cover skirt plates	others
$25+L_1/10$	$12.5+L_1/20$

(3) The load on hatch covers due to cargo loaded on said covers is to be obtained from the following **(a)** and **(b)**.

(3) Load cases with partial loading are also to be considered.

(a) Distributed load due to cargo load $P_{cargo}(kN/m^2)$resulting from heave and pitch is to be determined according to the following formula:

$$P_{cargo} = P_c(1 + a_V)$$

P_c: Static uniform cargo load (kN/m^2)

a_V: Acceleration addition given by the following formula:

$$a_V = \frac{0.11mV'}{\sqrt{L_1}}$$

m : As given by the following formulae:

$$m_0 - 5(m_0 - 1)\frac{x}{L_1} \quad \text{for} \quad 0 \leq \frac{x}{L_1} \leq 0.2$$

$$1.0 \quad \text{for} \quad 0.2 < \frac{x}{L_1} \leq 0.7$$

$$1 + \frac{m_0+1}{0.3}\left(\frac{x}{L_1} - 0.7\right) \quad \text{for} \quad 0.7 < \frac{x}{L_1} \leq 1.0$$

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 **1.2.8, Part 1 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 $F_{cargo}(kN)$due to a single force resulting from heave and pitch (e.g. in the case of containers) is to be determined by the following formula. When the load case of a partially loaded container is considered, the point load is at the discretion of the Society.

$$F_{cargo=} F_s(1 + a_V)$$

F_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)** and **(b)** are to be considered:

(a) Cargo loads (kN) due to heave, pitch and roll motion of the ship determined by the following formulae are to be considered (see **Fig. 19.1**). 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)

h_m: Design height of the centre of gravity of the stack above hatch cover supports (m)

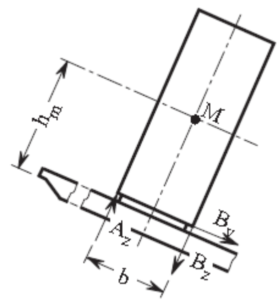
b: Distance between foot points (m)

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)

α_V: As specified in **(3)** above

Fig. 19.1 Forces due to Container Loads



(b) Details of the application of **(a)** above are to be in accordance with the following:

i) For the maximum design mass of container stack M and the design height of the centre of gravity of the stack above hatch cover supports h_m, it is recommended to apply the values which are used for the calculations of cargo securing (container lashing). If different assumptions are made for M and h_m, sufficient data which show that the hatch cover structure is not loaded by less than the recommended values is to be submitted.

ii) When the strength of a hatch cover structure is assessed by *FEM* analysis using shell or plane strain elements, h_m, may be taken as the design height of the centre of gravity of the stack above the hatch cover top plate.

iii) The values of M and h_m, applied for the assessment of hatch cover strength are to be shown in the drawings of the hatch covers.

iv) In the case of container stacks secured to lashing bridges or carried in cell guides, the forces acting on the hatch covers may be specially considered by the Society.

v) Container loads may be applied based on accelerations calculated by an individual acceleration analysis for the lashing system being used as deemed appropriate by the Society.

(5) In addition to the loads specified in **(1)** to **(4)** above, when the load in the ships 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)**.

19.2.5 Strength Criteria of Steel Hatch Covers and Hatch Beams

1. Permissible stresses and deflections

(1) The equivalent stress $\sigma_E (N/mm^2)$ in steel hatchway covers and steel weathertight covers are to be complied with the criteria as following **(a)** and **(b):**

(a) For beam element calculations and grillage analysis:

$$\sigma_E = \sqrt{\sigma^2 + 3\tau^2} \quad \leq 0.8\,\sigma_F$$

σ: Nominal stress (N/mm^2)

τ: Shear stress (N/mm^2)

σ_F. Minimum upper yield stress (N/mm^2) or proof stress (N/mm^2) of the material. However, when material with a σ_F of more than 355 N/mm^2 is used, the value for σ_F is to be taken as deemed appropriate by the Society.

(b) For *FEM* calculations, in cases where the calculations use shell or plane strain elements, the stresses are to be taken from the centre of the individual element.

$\sigma_E = \sqrt{\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau^2} \leq 0.8\,\sigma_F$ when assessed using the design load specified in **19.2.4(1)**

$\sigma_E = \sqrt{\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau^2} \leq 0.9\,\sigma_F$ when assessed using any other design loads

σ_x: Normal stress (N/mm^2) in the x –direction

σ_y: Normal stress (N/mm^2) in the y –direction

τ: 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_F: As specified in **(a)** above

(2) The equivalent stress σ_E (N/mm^2) in steel pontoon covers and hatch beams is not to be greater than 0.68 σ_F, where σ_F, is as specified in **(1)** above.

(3) 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 within hold cargo has to be observed.

2. Local net plate thickness of steel hatch covers

(1) The local net thickness τ_{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:

$$\tau_{net} = 15.8 F_p S \sqrt{\frac{P_{HC}}{0.95\sigma_F}}$$

F_p: Coefficient given by the following formula:

$1.9\ \sigma/\sigma_a$ (for $\frac{\sigma}{\sigma_a} \geq 0.8$, for the attached plate flange of primary supporting members)

1.5 (for $\frac{\sigma}{\sigma_a} < 0.8$, for the attached plate flange of primary supporting members)

σ: Normal stress (N/mm^2) of the attached plate flange of primary supporting members. The normal σ may be determined at a distance S from the webs of adjacent primary supporting members perpendicular to secondary stiffeners and at a distance *S/2* from the web of an adjacent primary supporting member parallel to secondary stiffeners, whichever is greater (see **Fig. 19.2**). The distribution of normal stress σ between two parallel girders is to be in accordance with **19.2.5-6.(3)(c).**

σ_a: Permissible stress (N/mm^2) is to be as given by following formula:

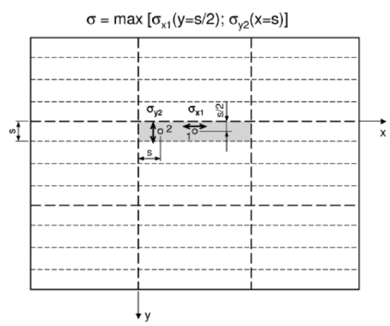
$\sigma_a = 0.8\sigma_F$

S: Stiffener spacing (m)

P_{HC}: Design load (kN/m^2) specified in **19.2.4(1)** and **19.2.4(3)(a)**

σ_F: Minimum upper yield stress (N/mm^2) or proof stress (N/mm^2) of the material

Fig. 19.2 Determination of the Normal Stress of Hatch Cover Plating



(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) In addition to **(2)** above, 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 that obtained from following formulae:

$t_{net} = 6.5S$

$t_{net} = 5$

S: As specified in **(1)** above

(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.

3. Net scantling of secondary stiffeners

(1) The net section modulus $Z_{net}(cm^3)$ of the secondary 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 secondary stiffeners is to be determined based on an attached plate width that is assumed to be equal to the stiffener spacing.

$$Z_{net} = \frac{104SP_{HC}l^2}{\sigma_F}$$

(l): Secondary 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.

S: Stiffener spacing (*m*)

P_{HC}: Design load *(kN/m^2)* as specified in **-2(1)** above

σ_F: Minimum upper yield stress (*N/mm^2*) or proof stress (*N/mm^2*) of the material.

(2) The net shear sectional area $A_{net}(cm^2)$of the secondary stiffener webs of hatch cover top plates is not to be less than that obtained from the following formula:

$$A_{net} = \frac{10SP_{HC}l}{\sigma_F}$$

l, S and P_{HC}: As specified in **(1)** above

(3) For flat bar secondary stiffeners and buckling stiffeners, the following formula is to be applied:

$$\frac{h}{t_{W,net}} \leq 15\sqrt{k}$$

h: Height (*mm*) of the stiffener

$t_{W,net}$: Net thickness (*mm*) of the stiffener

$k = 235/\sigma_F$

σ_F: As specified in **(1)** above

(4) Stiffeners parallel to primary supporting members and arranged within the effective breadth according to **19.2.5-5(2)** are to be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members.

(5) 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).**

(6) For hatch cover stiffeners under compression, sufficient safety against lateral and torsional buckling according to **19.2.5-6(3)** is to be verified.

4. Primary supporting members of steel hatch covers and hatch beams

(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) The scantlings of the primary supporting members of steel hatch covers and hatch beam with variable cross-sections are to be not less than that obtained from the following formulae. For steel hatchway covers, *S* and *l* are to be read as *b* and *S*, respectively.

The net section modulus (cm^3) of hatch beams or primary supporting members 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 or primary supporting members 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 **(1)** above

I_{net_cs}: Net moment of inertia (cm^4) complying with requirement **(1)** above

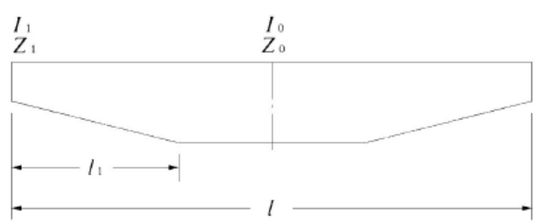
S: Spacing (m) of portable beams or primary supporting members

l: Unsupported span (m) of portable beams or primary supporting members

b: Width (m) of steel hatch covers

k_1 and k_2: Coefficients obtained from the formulae given in **Table 19.4**

Table 19.4 Coefficient k_1 and k_2

<table>
<tr><td>k_1</td><td>$1+\dfrac{3.2\alpha-\gamma-0.8}{7\gamma+0.4}$</td><td rowspan="2">$k_1$ is not to be taken as less than 1.0
$\alpha=\frac{l_1}{l}$ $\beta=\frac{I_1}{I_0}$ $\gamma=\frac{Z_1}{Z_0}$</td></tr>
<tr><td>k_2</td><td>$1+8\alpha^3\dfrac{1-\beta}{0.2+3\sqrt{\beta}}$</td></tr>
<tr><td colspan="3">l = Overall length of portable 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 o inertia at ends (cm^4)
Z_0 = Section modulus at ends (cm^3)
Z_1 =Section modulus at ends (cm^3)

</td></tr>
</table>

(3) In addition to **(1)** and **(2)** above, the scantlings of the primary supporting members of steel hatch cover are to comply with the requirements specified in **-6.**

(4) When biaxial compressed flange plates are considered, the effective width of flange plates is to comply with **19.2.5-6(3)**

(5) In addition to **(1)** to **(4)** 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:

$t_{net} = 6.5S$

$t_{net} = 6.5$

S: Stiffener spacing (m)

(6) In addition to **(1)** to **(5)** 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:

$t_{net} = 15.8S\sqrt{\frac{P_H}{0.95\sigma_F}}$

$t_{net} = 8.5S$

P_H: Design horizontal wave load (kN/m^2)as specified in **19.2.4(2)**

S: Stiffener spacing (m)

σ_F: Minimum upper yield stress (N/mm^2) or proof stress (N/mm^2) of the material

(7) 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:

$I = 6pa^4$

a: Maximum of the distance (m), a_i, between two consecutive securing devices, measured along the hatch cover periphery, not to be taken as less than $2.5a_C$ (m), (**see Fig. 19.3**)

a_c: max $(a_{1.1,}a_{1.2})$ (m) (**see Fig. 19.3**)

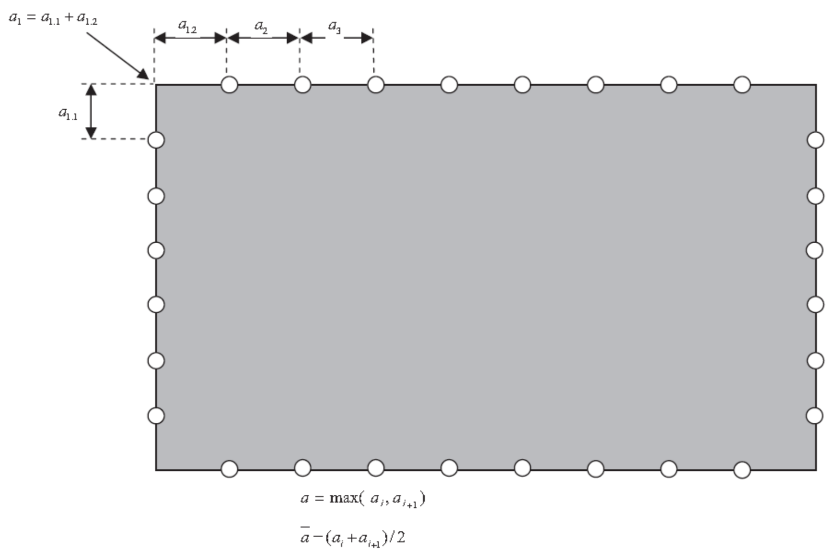
p: Packing line pressure (N/mm), minimum $5\ N/mm$

When calculating the actual gross moment of inertia of the edge element, the effective breadth of the attached plating of hatch covers is to be taken as equal to the lesser of the following values:

0.165a

Half the distance between the edge element and the adjacent primary member

Fig. 19.3 Distance between Security Devices, Measured Along Hatch Cover Periphery.



5. Strength calculation

(1) Strength calculation for steel hatch covers may be carried out by using beam theory, grillage analysis or *FEM*. Net scantlings are to be used for modeling.

(2) Effective cross-sectional properties for calculation by beam theory or grillage analysis are to be determined by the following **(a)** to **(e):**

(a) The effective breadth of attached plating e_m of the primary supporting members specified in **Table 19.5** according to the ratio of l and e is to be considered for the calculation of effective cross-sectional properties.

For intermediate values of l/e, e_m is to be obtained by linear interpolation.

(b) Separate calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

(c) The effective cross sectional areas of plates is not to be less than the cross sectional area of the face plate.

(d) The cross sectional area of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth may be included in the calculations (see **Fig. 19.5**).

(e) For flange plates under compression with secondary stiffeners perpendicular to the web of the primary supporting member, the effective width is to be determined according to **19.2.5-6(3)**

(3) General requirements for *FEM* are as follows:

(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) Element size is to be suitable to take effective breadth into account.

(d) In no case is element width to be larger than stiffener spacing. The ratio of element length to width is not to exceed 4.

(e) The element height of the webs of primary supporting members is not to exceed one-third of the web height.

Tabla 19.5 Effective Breadth e_m of Plating of Primary Supporting Members

l/e	0	1	2	3	4	5	6	7	8 and over
e_{m1}/e	0	0.36	0.64	0.82	0.91	0.96	0.98	1.00	1.00
e_{m2}/e	0	0.20	0.37	0.52	0.65	0.75	0.84	0.89	0.90

Notes

e_{m1}: Effective breadth (mm) to be applied where primary supporting members are loaded by uniformly distributed loads or by not less than 6 equally spaced single loads

e_{m2}: Effective breadth (mm) to be applied where primary supporting members are loaded by 3 or less single loads

l: Length between zero-points of bending moment curve taken equal to:

For simply supported primary supporting members: l_0

For primary supporting members with both ends constant: $0.6l_0$

l_0: Unsupported length of the primary supporting members

e Width of plating supported, measured from centre to centre of the adjacent unsupported fields

6. Buckling strength of steel hatch covers

The buckling strength of the structural members of steel hatch covers is to be in accordance with the following **(1)** to (**3**)**:**

(1) The buckling strength of a single plate panel of the top and lower steel hatch cover plating is to comply with following formulae:

$$\left(\frac{|\sigma_x|C_{sf}}{K_x\sigma_F}\right)^{e_1} + \left(\frac{|\sigma_y|C_{sf}}{K_y\sigma_F}\right)^{e_2} - B\left(\frac{\sigma_x\sigma_y C_{sf}^2}{\sigma_F^2}\right) + \left(\frac{|\tau|C_{sf}\sqrt{3}}{K_\tau\sigma_F}\right)^{e_2} \leq 1.0$$

$$\left(\frac{\sigma_x C_{sf}}{K_x\sigma_F}\right)^{e_1} \leq 1.0$$

$$\left(\frac{\sigma_y C_{sf}}{K_y \sigma_F}\right)^{e_2} \leq 1.0$$

$$\left(\frac{|\tau| C_{sf} \sqrt{3}}{K_\tau \sigma_F}\right)^{e_3} \leq 1.0$$

σ_x, σ_y: Membrane stress in the x-direction and the y-direction (*N/mm²*). In cases where the stresses are obtained from *FEM* and already contain the Poisson-effect, the following modified stress values may be used. Both stresses σ_x^* and σ_y^* are to be compressive stress in order to apply stress reduction according to the following formulae:

$$\sigma_x = (\sigma_x^* - 0.3\sigma_y^*)/0.91$$

$$\sigma_y = (\sigma_y^* - 0.3\sigma_x^*)/0.91$$

σ_x^* and σ_y^*: Stresses containing the Poisson-effect. These values are to comply with the following formulae:

$\sigma_y = 0$ and $\sigma_x = \sigma_x^*$ for $\sigma_y^* < 0.3\sigma_x^*$

$\sigma_x = 0$ and $\sigma_y = \sigma_y^*$ for $\sigma_x^* < 0.3\sigma_y^*$

τ: Shear stress (*N*/*mm²*) in *x*-*y* plane

σ_F: Minimum yield stress (*N/mm²*) of the material.

Compressive and shear stresses are to be taken as positive values and tension stresses are to be taken as negative values.

C_{sf}: Safety factor taken as equal to:

C_{sf}=1.25 for hatch covers when subjected to design vertical wave loads according to **19.2.4(1)**

C_{sf}=1.10 for hatch covers when subjected to loads according to **19.2.4(2) to (5)**

F_1: Correction factor for the boundary condition of stiffeners on the longer side of elementary plate panels according to **Table 19.6**

e_1, e_2, e_3 and *B*: Coefficient obtained from **Table 19.7**

K_x, K_y, and K_τ : Reduction factor obtained from **Table 19.8**. However, these values are to comply with the following formulae:

$K_x = 1.0$ for $\sigma_x \leq 0$ (tension stress)

K_y, = 1.0 for $\sigma_y \leq 0$ (tension stress)

a: Length (*mm)* of the longer side of the partial plate field (x -direction)

b: Length (*mm)* of the longer side of the partial plate field (y -direction)

n: Number of the elementary plate panel breadths within the partial or total plate panel **(see Fig. 19.4)**

α: Aspect ratio of a single plate field obtained from the following formula:

$$\alpha = \frac{a}{b}$$

λ : Reference degree of slenderness, taken as equal to:

$$\lambda = \sqrt{\frac{\sigma_F}{K\sigma_e}}$$

K: Buckling factor according to **Table 19.8**

σ_e: Reference stress (*N/mm²*), taken as equal to:

$$\sigma_e = 0.9E\left(\frac{t}{b}\right)^2$$

E: Modulus of elasticity (*N/mm²*) of the material, taken equal to:

$$E = 2.06x10^5$$

τ: Net thickness (*mm*) of plate under consideration

Ψ: Edge stress ratio taken as equal to:

$$\Psi = \frac{\sigma_2}{\sigma_1}$$

σ_1: Maximum compressive stress (*N/mm²*)

σ_2: Minimum compressive stress or tension stress *(N/mm²)*

Fig. 19.4 General Arrangement of Panels

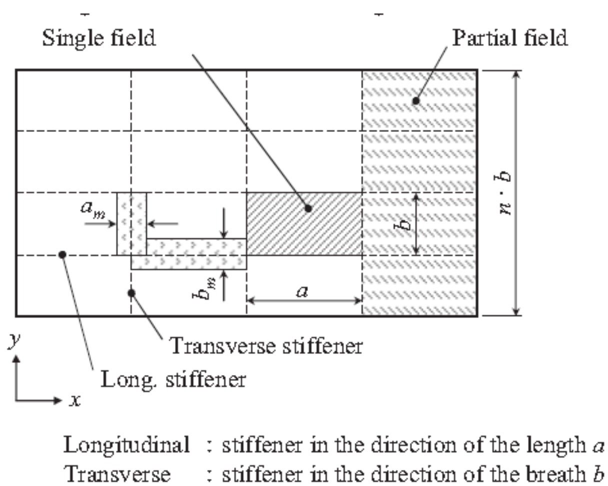


Tabla 19.6 Correction Factor F_1

Boundary condition	F_1 (2)	Edge stiffener
Stiffeners sniped at both ends	1.00	
Guidance value (1) where both ends are effectively connected to adjacent structures	1.05	Flat bars
	1.10	Bulb sections
	1.20	Angles and tee-sections
	1.30	U-type sections (3) and girders of high

		rigidity

(1) Exact values may be determined by direct calculations

(2) An average value may be taken if it is verified by a buckling strength check of the partial field using non-linear *FEA* and deemed appropriate by the Society .However, such values are not to be greater than 2.0

(3) A higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA and deemed appropriate by the Society. However, such values are not to be greater than 2.0

Table 19.7 Coefficient e_1, e_2, e_3 and B

Exponents e_1, e_2, e_3 and B		Plate panel
e_1		$1 + K_x^4$
e_2		$1 + K_y^4$
e_3		$1 + K_x K_y K_\tau^2$
B	For σ_x and σ_y positive (compressive stress)	$(K_x K_y)^5$
	For σ_x or σ_y negative (tension stress)	1

Table 19.8 Buckling and Reduction Factors for Plane Elementary Plate Panels

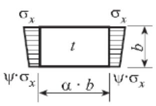
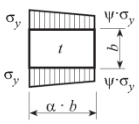
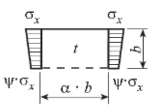
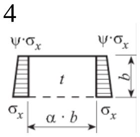
<table>
<tr><th>Load case</th><th>Edge stress ratio ψ</th><th>Aspect ratio $\alpha = {}^{a}/_{b}$</th><th>Buckling factor K</th><th>Reduction factor K</th></tr>
<tr><td rowspan="3">1

</td><td>$1 \geq \psi \geq 0$</td><td rowspan="3">$\alpha \geq 1$</td><td>$K = \frac{8.4}{\psi + 1.1}$</td><td rowspan="3">$K_x = 1 \;\; for\; \lambda \leq \lambda_c$
$K_x = c\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right) \;\; for\; \lambda > \lambda_c$
$c = (1.25 - 0.12\psi) \leq 1.25$
$\lambda_t = \frac{c}{2}\left(1 + \sqrt{1 \;\; \frac{0.88}{c}}\right)$</td></tr>
<tr><td>$0 > \psi > -1$</td><td>$K = 7.63 - \psi(6.26 - 1.0\psi)$</td></tr>
<tr><td>$\psi \leq -1$</td><td>$K = 5.975\,(1 - \psi)^2$</td></tr>
<tr><td rowspan="5">2

</td><td>$1 \geq \psi \geq 0$</td><td>$\alpha \geq 1$</td><td>$K = F_1\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1}{(\psi + 1.1)}$</td><td rowspan="4">$K_y = c\left(\frac{1}{\lambda} - \frac{R + F^2(H - R)}{\lambda^2}\right)$
$C - (1.25 - 0.12\psi) \leq 1.25$
$R = \lambda\left(1 - \frac{\lambda}{c}\right)$ for $\lambda < \lambda_c$
$R = 0.22$ for $\lambda \geq \lambda_c$
$\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0.88}{c}}\right)$
$F = \left(1 - \frac{\frac{K}{0.91} - 1}{\lambda_p^2}\right) c_1 \geq 0$
$\lambda_p^2 = \lambda^2 - 0.5$ for $1 \leq \lambda_p^2 \leq 3$
$c_1 = \left(1 - \frac{F_1}{\alpha}\right) \geq 0$
$H = \lambda - \frac{2\lambda}{c\left(T + \sqrt{T^2 - 4}\right)} \geq R$
$T - \lambda + \frac{14}{15\lambda} + \frac{1}{3}$</td></tr>
<tr><td rowspan="2">$0 > \psi > 1$</td><td>$1 \leq \alpha \leq 1.5$</td><td>$K \;\; F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1(1 + \psi)}{1.1} - \frac{\psi}{\alpha^2}\,(13.9 \;\; 10\psi)\right]$</td></tr>
<tr><td>$\alpha > 1.5$</td><td>$K = F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1(1 + \psi)}{1.1} - \frac{\psi}{\alpha^2}\left(5.87 + 1.87\alpha^2 + \frac{8.6}{\alpha^2} \;\; 10\psi\right)\right]$</td></tr>
<tr><td rowspan="2">$\psi \leq 1$</td><td>$1 \leq \alpha \leq \frac{3(1 - \psi)}{4}$</td><td>$K = 5.95F_1\left(\frac{1 - \psi}{\alpha}\right)^2$</td></tr>
<tr><td>$\alpha > \frac{3(1 \;\; \psi)}{4}$</td><td>$K = F_l\left[3.9675\left(\frac{1 - \psi}{\alpha}\right)^2 + 0.5375\left(\frac{1 - \psi}{\alpha}\right)^4 + 1.87\right]^2$</td><td rowspan="4">$K_x = 1$ for $\lambda \leq 0.7$
$K_x = \frac{1}{\lambda^2 + 0.51} \quad \lambda > 0.7$</td></tr>
<tr><td rowspan="2">3

</td><td>$1 > \psi \geq 0$</td><td rowspan="2">$\alpha > 0$</td><td>$K = \frac{4\left(0.425 + \frac{1}{\alpha^2}\right)}{3\psi + 1}$</td></tr>
<tr><td>$0 > \psi > -1$</td><td>$K \;\; 4\left(0.425 + \frac{1}{\alpha^2}\right)(1 + \psi)$
$5_\psi(1 - 3.42\psi)$</td></tr>
<tr><td>4

</td><td>$1 \geq \psi > -1$</td><td>$\alpha > 0$</td><td>$K = \left(0.425 + \frac{1}{\alpha^2}\right)\frac{3 \;\; \psi}{2}$</td></tr>
</table>

Table 19.8 Buckling and Reduction Factors for Plane Elementary Plate Panels (continued)

Load Case	Edge stress ratio Ψ	Aspect ratio $\alpha - a/b$	Buckling factor K	Reduction factor K
5	-		$K - K_\tau\sqrt{3}$	$K_\tau = 1$ for $\lambda \leq 0.84$ $K_\tau = \frac{0.84}{\lambda}$ for $\lambda > 0.84$
		$\alpha \geq 1$	$K_\tau = \left[5.34 + \frac{4}{\alpha^2}\right]$	
			$K_\tau = \left[4 + \frac{5.34}{\alpha^2}\right]$	
Boundary condition - - - - - plate edge free ―――― plate edge simple support				

(2) The buckling strength of non-stiffened webs and the flanges of primary supporting members are to be according to requirement of **(1)** above.

(3) The buckling strength of partial and total fields included in the structural members of steel hatch covers is to comply with the following **(a)** to **(e):**

(a) The buckling strength of longitudinal and transverse secondary stiffeners is to comply with following **(d)** and **(e):**

(b) When buckling calculation is carried out according to **(d)** and **(e),** the effective breadth of steel hatch cover plating may be in accordance with following **i)** and **ii)**:

i) The effective breadth a_m or b_m of attached plating may be determined by the following formulae **(see Fig. 19.4).** However, the effective breadth of plating is not to be taken greater than the value obtained from **19.2.5-5.**

$b_m = K_x b$ for longitudinal stiffeners

$a_m = K_y a$ for transverse stiffeners

K_x and K_y: As obtained from **Table 19.8**

a and b: As specified **(1)** above

ii) The effective breadth $e_m^{'}$ of stiffened flange plates of primary supporting members may be determined according to the following **1)** and **2)**. However, a_m and b_m for flange plates are in general to determined for Ψ = 1.

1) Stiffening parallel to the webs of primary supporting members (see **Fig. 19.5**). For $b \geq e_m$, b and a have to be exchanged.

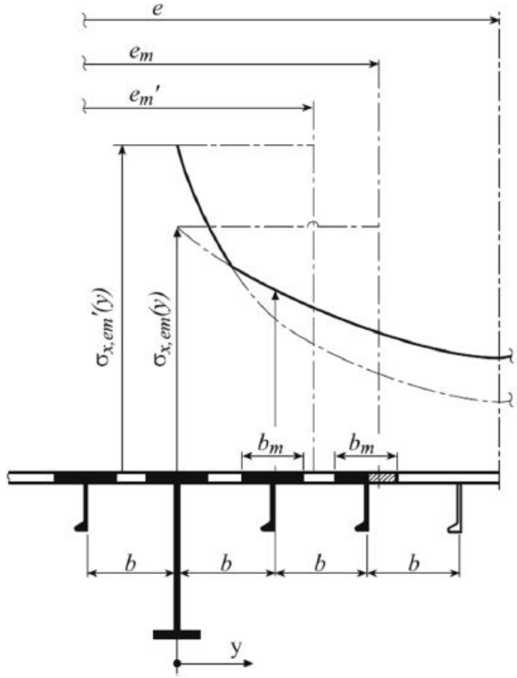
$b < e_m$

$e_m^{'} = nb_m$

n: Integer number of stiffener spacing b inside the effective breadth e_m according to **19.2.5-5**, taken as equal to:

$n = int\left(\frac{e_m}{b}\right)$

Fig. 19.5 Stiffening Parallel to Web of Primary Supporting Member



2) Stiffening perpendicular to the webs of primary supporting members (see **Fig. 19.6**).

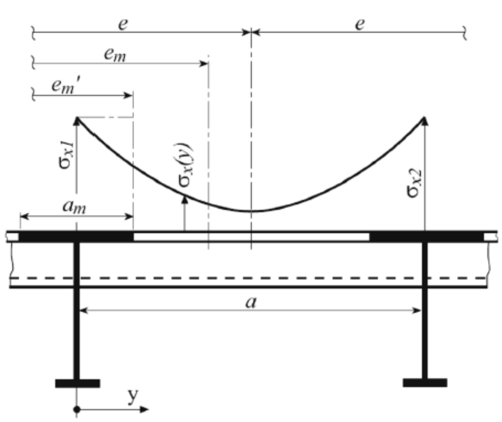
For $a < e_m$, a and b have to be exchanged

$a \geq e_m$

$e_m^{'} = n a_m < e_m$

$n = 2.7 \dfrac{e_m}{a} \leq 1$

Fig. 19.6 Stiffening Perpendicular to Web of Primary Supporting Member



(c) Stresses obtained from the calculation of the scantlings of plating and the stiffeners of steel hatch covers are to comply with the following:

i) The scantlings of plates and stiffeners are in general to be determined according to the maximum stresses $\sigma_x(y)$at the webs of primary supporting members and stiffeners respectively.

ii) For stiffeners with spacing b under compression arranged parallel to primary supporting members no value less than $0.25\sigma_F$ is to be inserted for $\sigma_x(y = b)$.

iii) The stress distribution between two primary supporting members may be obtained by the following formula:

$$\sigma_x(y) = \sigma_{x1}\left\{1 - \frac{y}{e}\left[3 + C_1 - 4C_2 - 2\frac{y}{e}(1 + c_1 - 2C_2)\right]\right\}$$

C_1: As given by the following formula:

$C_1 = \frac{\sigma_{x1}}{\sigma_{x2}}$, however $0 \leq C_1 \leq 1$

C_2: As given by the following formula:

$$C_2 = \frac{1.5}{e}\left(e''_{m1} + e''_{m2}\right) - 0.5$$

σ_{x1} and σ_{x2}: Normal stresses in the flange plates of adjacent primary supporting members 1 and 2 with spacing e, based on cross-sectional properties considering the effective breadth or effective width, as appropriate

e''_{m1}: Proportionate effective breadth e''_{m1} or proportionate effective width e'_{m1} of primary supporting member 1 within the distance e, as appropriate

e''_{m2}: Proportionate effective breadth e''_{m2} or proportionate effective width e'_{m2} of primary supporting member 2 within the distance e, as appropriate

iv) The shear stress distribution in flange plates may be assumed to be linear.

(d) For lateral buckling, longitudinal and transverse stiffeners are to comply with following **i)** to **iii)**:

i) Secondary stiffeners subject to lateral loads are to comply with the following criteria:

$$\frac{\sigma_a + \sigma_b}{\sigma_F} \; C_{sf} \leq 1$$

σ_a: Uniformly distributed compressive stress (*N/mm²*) in the direction of the stiffener axis, given by the following formula:

$\sigma_a = \sigma_x$ for longitudinal stiffeners

$\sigma_a = \sigma_y$ for transverse stiffeners

σ_b: Bending stress (*N/mm²*) in the stiffeners, given by the following formula

$\sigma_b = \frac{M_0 + M_1}{Z_{st}10^3}$ with $\sigma_x = \sigma_n$ and $\tau = \tau_{SF}$

M_0: Bending moment (*N-mm*) due to deformation w of stiffener, given by the following formula:

$M_0 = F_{Ki}\,\frac{P_z w}{C_f - p_Z}$ with $(C_f - p_Z) > 0$

M_1: Bending moment (*N-mm*) due to lateral load *P* given by the following formula:

$M_1 = \frac{Pba^2}{24 \cdot 10^3}$ for longitudinal stiffeners

$M_1 = \frac{P(nb)^2}{8c_S 10^3}$ for transverse stiffeners. Where *n* is to be taken as equal to 1 for ordinary transverse stiffeners

Z_{st}: Section modulus of stiffener (*cm*^{3}) including the effective breadth of plating according to **19.2.5-6(3)**

c_S: Factor accounting for the boundary conditions of the transverse stiffener taken as equal to:

c_S: 1.0 for a stiffener that is simply supported

c_S: 2.0 for a stiffener that is partially constrained

P: Lateral load (*kN/m*^{2}) as specified in **19.2.4** according to the condition under consideration

F_{ki}: Ideal buckling force (*N*) of the stiffener given by the following formula

$F_{kix} = \frac{\pi^2}{a^2} EI_x 10^4$ for longitudinal stiffeners

$F_{kiy} = \frac{\pi^2}{nb^2} EI_y 10^4$ for transverse stiffeners

I_x and I_y: Net moments of inertia (*cm*^{4}) of the longitudinal or transverse stiffener, including the effective breadth of attached plating according to **19.2.5-6(3).** I_x and I_y are to comply with the following criteria:

$$I_x \geq \frac{bt^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{at^3}{12 \cdot 10^4}$$

P_2: Nominal lateral load (*N/mm*^{2}) of the stiffener due to σ_x, σ_y and τ

$P_{zx} = \frac{t_a}{b}\left(\sigma_{xl}\left(\frac{\pi b}{a}\right)^2 + 2c_y\sigma_y + \tau_1\sqrt{2}\right)$ for longitudinal stiffeners

$P_{zy} = \frac{t_a}{b}\left(2c_x\sigma_{xl} + \sigma_y\left(\frac{\pi a}{nb}\right)^2\left(1 + \frac{A_y}{at_a}\right) + \tau_1\sqrt{2}\right)$ for transverse stiffeners

t_a: Net thickness (*mm*) of attached plating

c_x and c_y: Factor taking into account the stresses vertical to the stiffener's axis and distributed variable along the stiffener s length taken as equal to:

$0.5(1+\Psi)$ for $0 \leq \Psi \leq 1$

$\frac{0.5}{1-\Psi}$ for $\Psi < 0$

A_x and A_y : Net sectional area (*mm*^{2}) of the longitudinal or transverse stiffener respectively without attached plating

$$\sigma_{xl} = \sigma_x\left(1 + \frac{A_x}{bt_a}\right)$$

$$t_1 = \left[\tau - t\sqrt{\sigma_F E\left(\frac{m_1}{a^2} + \frac{m_2}{b^2}\right)}\right] \geq 0$$

m_1 and m_2 Coefficient given by the following formulae:

For longitudinal stiffeners:

$m_1 = 1.47$ $m_2 = 0.49$ for $\frac{a}{b} \geq 2.0$

$m_1 = 1.96$ $m_2 = 0.37$ for $\frac{a}{b} < 2.0$

For transverse stiffeners

$m_1 = 0.37$ $m_2 = \frac{1.96}{n^2}$ for $\frac{a}{nb} \geq 0.5$

$m_1 = 0.49$ $m_2 = \frac{1.47}{n^2}$ for $\frac{a}{nb} < 0.5$

$w = w_0 + w_1$

w_0: Assumed imperfection (*mm*) taken as equal to:

$w_0 = \min\left(\frac{a}{250}, \frac{b}{250}, 10\right)$ for longitudinal stiffeners

$w_0 = \min\left(\frac{a}{250}, \frac{nb}{250}, 10\right)$ for transverse stiffeners

For stiffeners sniped at both ends w_0 is not to be taken as less than the distance from the mid-point of attached plating to the neutral axis of the stiffener calculated with the effective width of its attached plating.

w_1: Deformation of stiffener (*mm*) at the mid-point of stiffener span due to lateral load p. In the case of uniformly distributed loads, the following values for w_1 may be used:

$w_1 = \frac{Pba^4}{384 \cdot 10^7 \, EI_x}$ for longitudinal stiffeners

$w_1 = \frac{5Pa(nb)^4}{384 \cdot 10^7 \, EI_y c_S^2}$ for transverse stiffeners

c_f: Elastic support (*N/mm*^{2}) provided by the stiffener taken as equal to:

For longitudinal stiffeners:

$$c_f = F_{kix} \frac{\pi^2}{a^2}\left(1 + c_{px}\right)$$

$$c_{px} = \frac{1}{1 + \frac{0.91\left(\frac{12 \cdot 10^4 I_x}{t^3 b} - 1\right)}{c_{xa}}}$$

c_{xa}: Coefficient taken as equal to:

$$c_{xa} = \left[\frac{a}{2b} + \frac{2b}{a}\right]^2 \quad \text{for } a \geq 2b$$

$$c_{xa} = \left[1 + \left(\frac{a}{2b}\right)^2\right]^2 \quad \text{for } a < 2b$$

For transverse stiffeners:

$$c_f = c_S F_{kiy} \frac{\pi^2}{(n \cdot b)^2}\left(1 + c_{py}\right)$$

$$c_{py} = \frac{1}{1 + \dfrac{0.91\left(\dfrac{12 \cdot 10^4 I_y}{t^3 b} - 1\right)}{c_{ya}}}$$

c_{ya}: Coefficient taken as equal to:

$$c_{ya} = \left[\frac{nb}{2a} + \frac{2a}{nb}\right]^2 \quad \text{for } nb \geq 2a$$

$$c_{ya} = \left[1 + \left(\frac{nb}{2a}\right)^2\right]^2 \quad \text{for } nb < 2a$$

ii) For stiffeners not subject to lateral loads, the bending moment σ_b is to be calculated at the mid-point of the stiffener.

iii) When lateral loads are acting, stress calculations are to be carried out for both fibres of the stiffener s cross sectional area (if necessary for the biaxial stress field at the plating side).

(e) For torsional buckling, longitudinal and transverse stiffeners are to comply with the following **i)** and **ii)**:

i) Longitudinal stiffeners are to comply with following criteria:

$$\frac{\sigma_x}{K_T \sigma_F} C_{sf} \leq 1.0$$

K_T: Coefficient taken as equal to:

$$K_T = 1.0 \qquad \text{for } \lambda_T \leq 0.2$$

$$K_T = \frac{1}{\phi + \sqrt{\phi^2 - \lambda_T^2}} \qquad \text{for } \lambda_T > 0.2$$

$$\phi = 0.5(1 + 0.21(\lambda_T - 0.2) + \lambda_T^2)$$

λ_T: Reference degree of slenderness taken as equal to:

$$\lambda_T = \sqrt{\frac{\sigma_F}{\sigma_{kit}}}$$

$$\sigma_{KiT} = \frac{E}{I_p}\left(\frac{\pi^2 I_\omega 10^2}{a^2} \varepsilon + 0.385 I_T\right) (N/mm^2)$$

I_p: Net polar moment of inertia of the stiffener (cm^4) defined in **Table 19.9**, and related to point *C* as shown **in Fig. 19.7**

I_T: Net St. Venant's moment of inertia of the stiffener (cm^4) defined in **Table 19.9**

I_ω: Net sectorial moment of inertia of the stiffener (cm^6) defined in **Table 19.9**, related to point *C* as shown in **Fig. 19.7**

ε: Degree of fixation taken as equal to:

$$\varepsilon = 1 + 10^{-3} \sqrt{\frac{a^4}{\frac{3}{4}\pi^4 I_w \left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

A_w: Net web area (mm^2) equal to:

$$A_w = h_w\, t_w$$

A_f: Net flange area (mm^2) equal to:

$$A_f = b_f t_f$$

$$e_f = h_w + \frac{t_f}{2} (mm)$$

h_w,t_w, b_f and t_f: Dimensions of stiffener (mm) as specified in **Fig. 19.7**

Fig. 19.7 Dimensions of Stiffener

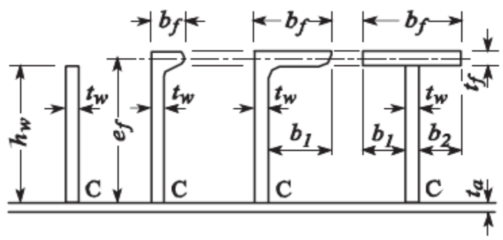


Table 19.9 Moments of Inertia

Section	I_p	I_T	I_ω
Flat bar	$\frac{h_w^3 t_w}{3 \cdot 10^4}$	$\frac{h_w t_w^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$	$\frac{h_w^3 t_w^3}{36 \cdot 10^6}$
Bulb, angle or tee sections	$\left(\frac{A_w h_w^2}{3} + A_f e_f^2\right) 10^{-4}$	$\frac{h_w t_w^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$ + $\frac{b_f t_f^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_f}{b_f}\right)$	For bulb and angle sections: $\frac{A_f e_f^2 b_f^2}{12 \cdot 16^6}\left(\frac{A_f + 2.6A_w}{A_f + A_w}\right)$ For tee-sections: $\frac{b_f^3 t_f e_f^2}{12 \cdot 10^6}$

ii) For transverse secondary stiffeners loaded by compressive stress which are not supported by longitudinal stiffeners, sufficient torsional buckling strength is to be performed analogously in accordance with **i)** above

19.2.6 Additional Requirements for Steel Hatch Covers Carrying Cargoes

1. Where concentrated loads, e.g. container loads, are acting on steel hatch covers, direct calculations deemed appropriate by the Society are required.

2. 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 this section.

3. The scantlings of top plates and stiffeners of steel hatch covers subject to wheel loads are determined by direct calculation or any other method which deemed appropriate by the Society.

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 **(7):**

(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.

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 7, Part 5** 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:

$$t_{coam,net} = 14.2S\sqrt{\frac{P_H}{\sigma_{a,coam}}}, \text{ but not be less than } 6 + \frac{L'}{100}$$

S: Secondary stiffener spacing (*m*)

P_H: As specified in **19.2.4(2)**

$\sigma_{a,coam} = 0.95\sigma_F$

σ_F: Minimum upper yield stress (*N/mm*^{2}) or proof stress (*N/mm*^{2}) of the material

L': Length of ship L_1 (*m*)

(2) Where the hatch coaming secondary 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:

$$t_{coam,gross} = 19.6\sqrt{\frac{P_H S(l-0.5S)}{\sigma_F}}$$

l: Secondary stiffener span (m) to be taken as the spacing of coaming stays

S, P_H and σ_F As specified in **(1)** above

(3) The net section modulus Z_{net} (cm^3) and net shear area (cm^2) of hatch coaming secondary stiffeners are not to be less than that obtained from the following formula. For snipped stiffeners at coaming corners, section modulus and shear area at the fixed support are to be increased by 35%.

$$Z_{net} = \frac{83\ S\ l^2\ P_H}{\sigma_F}$$

$$A_{net} = \frac{10\ S\ l\ P_H}{\sigma_F}$$

S, l, P_H and σ_F As specified in **(2)** above

(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 **(d):**

(a) The net section modulus Z_{net} (cm^3) of coaming stays with a height of less than 1.6 m is not to be less than that obtained from following formula .

$$Z_{net} = \frac{526 H_C^2 S P_H}{\sigma_F}$$

H_c: Hatch coaming stay height (m)

S: Hatch coaming stay spacing (m)

σ_F and P_H: As specified in **(1)** above

(b) The scantlings of hatch coaming stays with a height of 1.6 m and over are to be determined by direct calculations. The effective breadth of the coaming plate is to be in accordance with **19.2.5-5(2)** and stresses in hatch coaming stays are to comply with the criteria specified in **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.

(d) The net scantling $t_{w,net}$, (mm) of hatch coaming stay webs is not to be less than that obtained from the following formula:

$$t_{w,net} = \frac{2 H_c S P_H}{\sigma_F h}$$

h: Hatch coaming stay depth (m)

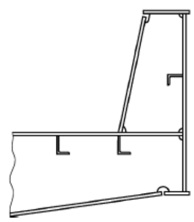
H_c, S, P_H and σ_F: As specified in **(a)** above

3. The coamings for hatchways in Position I or coamings of 760 *mm* or more in height for hatchways in Position II are to be stiffened in a suitable position below the upper edge by a horizontal stiffener; the breadth of the horizontal stiffener is not to be less than 180 *mm*.

4. Coamings are to be additionally supported by efficient brackets or stays provided from the horizontal stiffeners specified in **-3** to the deck at intervals of approximately 3 metres.

5. Coaming plates are to extend to the lower edge of the deck beams; moreover, they are to be flanged or fitted with face bars or half-round bars (see **Fig. 19.8**), except where specially approved by the Society.

Fig. 19.8 Example for the extension of coaming plates



6. 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 $0.1L_1$ 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 through steel to steel contact.

(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 **iii)**:

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.

(c) Securing devices attached to hatchway coamings, decks or covers are to be in compliance with the following **i)** to **v)**:

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 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.

$$A = 0.28ap/f$$

a: Half the distance (m) between two adjacent securing devices, measured along the hatch cover periphery (see **Fig. 19.3**)

p: Packing line pressure (N/mm), minimum 5 N/mm

f: As obtained from the following formula:

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

σ_F: Minimum upper yield stress (*N/mm²*) of the steel used for fabrication, but not to be taken greater than 70% of the ultimate tensile strength

e: Coefficient taken as equal to:

1.0 for $\sigma_F \leq 235\ N/mm^2$

0.75 for $\sigma_F > 235\ N/mm^2$

iii) Individual securing devices on each cover are to have approximately the same stiffness characteristics.

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

v) 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.

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.

(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.

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. 19.9**). Unsymmetrical loading, which may occur in practice, is to be considered. Under such loading, the equivalent stress (*N/mm²*) 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

$$k_l = \left(\frac{235}{\sigma_F}\right)^e$$

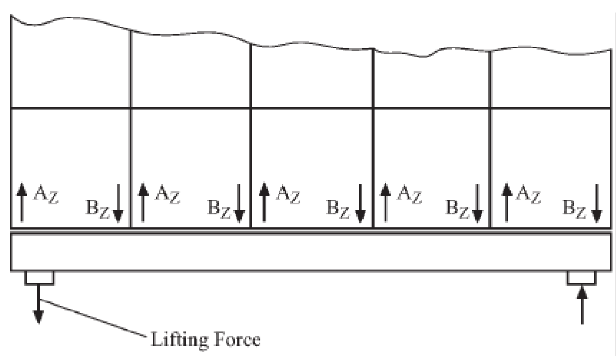
σ_F: Minimum upper yield stress (*N/mm*^{2}) or proof stress (*N/mm*^{2}) of the material

e: As given below

0.75 for $\sigma_F > 235$

1.00 for $\sigma_F \leq 235$

Fig. 19.9 Lifting forces at a hatch cover



19.2.11 Hatch Cover Supports, Stoppers and Supporting Structures

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.

$F = ma$

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 is not to be greater than that obtained from the following formula:

$p_{nmax} = dp_n$ in general

$p_{nmax} = 3p_n$ 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: Length of ship specified in **1.2.2, Part 1A** (m). However, L_1 need not be greater than 97% of the total length at the summer load waterline.

p_n: As obtained from **Table 19.10**

Table 19.10 Pernissible nominal surface pressure p_n

Material	p_n when loaded by	
	Vertical force	Horizontal forcé (on stoppers)
Hull structure steel	25	40
Hardened steel	35	50
Plastic material son steel	50	-

(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 related to long time stress is to be specified.

(d) Sufficient abrasive strength may be shown by tests demonstrating an abrasion of support surfaces of not more than 0.3 *mm* per year in service at a total distance of shifting of 15,000 *m* per year when deemed necessary 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.

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

Small hatches located on exposed decks forward of $0.25L_1$ 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 $0.1L_1$ or 22 *m* above the designed maximum load line, whichever is smaller. The length L_1 is specified in **15.2.1-1**.

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 stiffness 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 center 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:

$$9.1 + 0.134 d_t h \quad (mm)$$

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 *meters* 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.

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*: $0.7 + 0.035l + a(m^2)$

Where l is more than 20*m*: $0.07l + a(m^2)$

l : Length of bulwark (*m*), but need not be taken as greater than $0.7L_f$

a : As obtained from the following formulae.

Where h is more than 1.2*m*: $0.04l(h - 1.2) \quad (m^2)$

Where h is not more than 1.2*m*, but not less than 0.9*m*: $0 \quad (m^2)$

Where h is less than 0.9m: $-0.04l(0.9 - h) \quad (m^2)$

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 of *ILLC*.

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 21.1.**

Table 21.1 Area of Freeing Ports

Breadth of hatchway or trunk (*m*)	Area of freeing ports in relation to the total area of bulwark
$0.4B_f$ or less	0.2
$0.4B_f$ 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 weatertight 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 and inner doors are to be arranged so as to preclude the possibility of the door causing structural damage to the inner door or to the bulkhead when damage to or detachment of the door 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 $t = 80/K (N/mm^2)$

Bending stress $\sigma = 120/K (N/mm^2)$

Equivalent stress $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 150/K \quad (N/mm^2)$

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 σ_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:

$$\frac{125}{K} \quad (N/mm^2)$$

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:

$$P_e = 2.75C_H(0.22 + 0.15\tan\alpha)\left(0.4V\sin\beta + 0.6\sqrt{L}\right)^2 \quad (kN/m^2)$$

$C_H = 0.0125L \quad (for\ L < 80m)$

$1.0 \quad (for\ L \geq 80m)$

V : Speed of ship, in knots, as specified in **1.2.8, Part 1A**.

L : Length of ship, in m, as specified in **1.2.2, Part 1A**.

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:

$F_x = P_eA_x(kN)$

$F_y = P_eA_y(kN)$

$F_z = P_eA_z(kN)$

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:

$$M_y = F_x a + 10Wc - F_z b$$

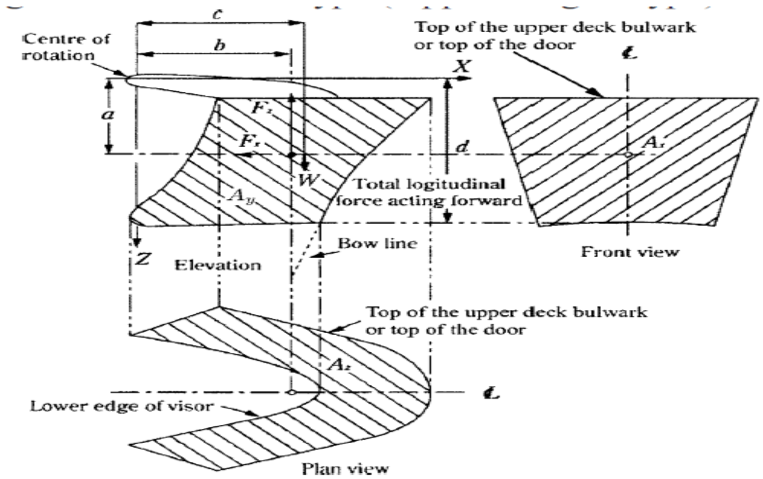
W : Mass of the visor door, in ton,

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. 21.3**

b : Horizontal distance, in *m*, from the visor pivot to the centroid of the projected area of the visor door, as shown in **Fig. 21.3**

c : Horizontal distance, in *m*, from the visor pivot to the center of gravity of visor mass, as shown in **Fig. 21.3**

Fig. 21.3 Visor type (Upper Hinged Type) Door



(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.

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 are 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}:

$$M_{y0} = 10Wc + 0.1\sqrt{a^2 + b^2}\sqrt{F_x^2 + F_z^2} \qquad (kN - m)$$

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 Ax . 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**

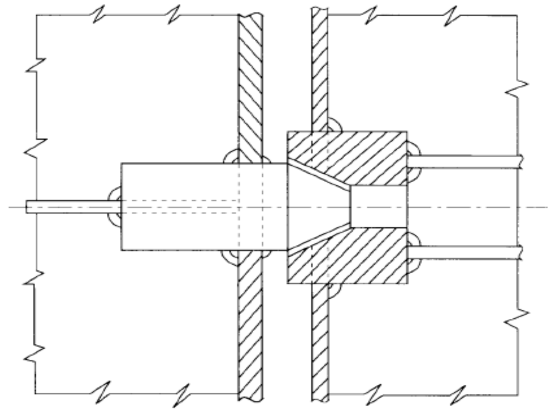
(8) For visor doors, the securing and supporting devices excluding the hinges should be capable of resisting the vertical design forces $(F_z - 10W)$ within the permissible stresses given in **21.3.3-1.**

(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. 21.4**). 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. 21.4 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 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, class, statutory certificates
- (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 watertight.

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 : $\tau = \frac{80}{K} \quad (N/mm^2)$

bending stress : $\sigma = \frac{120}{K} \quad (N/mm^2)$

equivalent stress : $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = \frac{150}{K} \quad (N/mm^2)$

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 21.2** respectively.

Table 21.2 Design Loads

		$F_e(kN)$ ((External force)	$F_i\ (kN)$ (Internal force)
Securing and supporting devices	Door opening inwards	$AP_e + F_p$	$F_o + 10W$
	Door opening outwards	AP_e	$F_o + 10W + F_p$
Primary members [1)]		AP_e	$F_o + 10W$

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 $.5N/mm$

F_o : 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 $30m^2$, the valve of F_c may be appropriately reduced to 10A

(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 21.3**

Table 21.3 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 $L < 80m$: $0.0125L$

where $L \geq 80m$: 1

L : Length of ship, in *m*, as specified in **1.2.2, Part 1A**

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:

$$8d^4F_p \quad (cm^4)$$

Where:

d: Distance between securing device (m)

F_p: See Notes for **Table 21.2**.

(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, class, statutory certificates
  (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 subdivision length (L_s) specified in **4.1.2(6)** 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(11)**

(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 8, Part 5** of the Rules 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 usually 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 21.4**) determined by their nominal diameters and grades. The design pressure P is to be determined using the following equation.

$$P = 10ac(0.067bL - y) \quad (kPa)$$

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 21.5**.

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 21.4 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 21.5 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 9, Part 5** of the Rules 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 21.6**) 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 21.5**

Table 21.6 Maximum allowable pressure of rectangular windows

Class	Nominal size width (*mm*) X height(*mm*)	Glass thickness (*mm*)	Máximum allowable pressure (*kPa*)
E	300X 425	10	99
	355X 500	10	71
	400X 560	12	80
	450X 630	12	63
	500X 710	15	80
	560X 800	15	64
	900X 630	19	81
	1000X 710	19	64
F	300X 425	8	63
	355X 500	8	45
	400X 560	8	36
	450X 630	8	28
	500X 710	10	36
	560X 800	10	28
	900X 630	12	32
	1000X 710	12	25
	1100X800	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 21.7. 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 21.7

Table 21.7 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 height of~~ the coaming of any ventilator ~~exceeds~~

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 extend 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. 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 $0.25L_1$ 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 $0.1L_1$ or 22 *m* above the designed maximum load line, whichever is smaller. The length L_1 is specified in **14.2.1-1. Part 2**.

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 *meters* in length; 57 *mm* for ships between 61 *meters* and 76 *meters* in length; 63 *mm* for ships greater than 76 *meters* 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 / IMO resolution MEPC.215 (82) as may be amended).

Chapter 23 EQUIPMENT

23.1 Anchors, Chain Cables and Ropes

23.1.1 General

1. All ships, according to their equipment numbers, are to be provided with anchors, chain cables, ropes, etc. which are not less than that given in **Table 23.1**.

2. Anchors, chain cables, ropes, etc. for ships having equipment numbers not more than 50 or more than 1670 are to be determined by the Society.

3. Two of the anchors given in **Table 23.1**. are to be connected to their cables and be positioned on board ready for use.

4. Anchors, chain cables, wire ropes and fibre ropes are to be in compliance with the requirements in **Chapter 2, 3.1 of Chapter 3, Chapter 4 , 5, and 6 Part 5**.

Table 23.1 Anchors, Chain Cables and Ropes

Equipment letter	Equipment number		Anchor		Chain cable for anchor (stud anchor for chain)				Tow line			Mooring line			
			number	Mass per anchor (stock-less anchor)	Total length	Diameter			Length	Beaking load		number	Length of each line	Breaking load	
						Grade 1	Grade 2	Grade 3							
	Over	Up to		Kg	*m*	*mm*	*mm*	*mm*	*m*		*kN*		*m*		*kN*
A1	50	70	2	180	220	14	12.5		180	↑	98	3	80	↑	34
A2	70	90	2	240	220	16	14		180	:	98	3	100	:	37
A3	90	110	2	300	247.5	17.5	16		180	:	98	3	110	:	39
A4	110	130	2	360	247.5	19	17.5		180	:	98	3	110	:	44
A5	130	150	2	420	275	20.5	17.5		180	:	98	3	120	:	49
B1	150	175	2	480	275	22	19		180	:	98	3	120	:	54
B2	175	205	2	570	302.5	24	20.5		180	●	112	3	120	:	59
B3	205	240	2	660	302.5	26	22	20.5	180	:	129	4	120	:	64
B4	240	280	2	780	330	28	24	22	180	:	150	4	120	:	69
B5	280	320	2	900	357.5	30	26	24	180	:	174	4	140	:	74
C1	320	360	2	1020	357.5	32	28	24	180	↓	207	4	140	●	78
C2	360	400	2	1140	385	34	30	26	180	↑	224	4	140	:	88
C3	400	450	2	1290	385	36	32	28	180	:	250	4	140	:	98
C4	450	500	2	1440	412.5	38	34	30	180	:	277	4	140	:	108
C5	500	550	2	1590	412.5	40	34	30	190	:	306	4	160	:	123
D1	550	600	2	1740	440	42	36	32	190	○	338	4	160	:	132
D2	600	660	2	1920	440	44	38	34	190	:	371	4	160	:	147
D3	660	720	2	2100	440	46	40	36	190	:	406	4	160	:	157
D4	720	780	2	2280	467.5	48	42	36	190	:	441	4	170	:	172
D5	780	840	2	2460	467.5	50	44	38	190	↓	480	4	170	:	186
E1	840	910	2	2640	467.5	52	46	40	190	↑	518	4	170	:	201
E2	910	980	2	2850	495	54	48	42	190	:	559	4	170	↓	216
E3	980	1060	2	3060	495	56	50	44	200	:	603	4	180	↑	230
E4	1060	1140	2	3300	495	58	50	46	200	:	647	4	180	:	250
E5	1140	1220	2	3540	522.5	60	52	46	200	:	691	4	180	:	270
F1	1220	1300	2	3780	522.5	62	54	48	200	:	738	4	180	:	284
F2	1300	1390	2	4050	522.5	64	56	50	200	:	786	4	180	:	309
F3	1390	1480	2	4320	550	66	58	50	200	:	836	4	180	:	324
F4	1480	1570	2	4590	550	68	60	52	220	◎	888	5	190	:	324
F5	1570	1670	2	4890	550	70	62	54	220	:	941	5	190	:	333

Notes:

1 Where steel wire ropes are used, the following wire ropes corresponding to the marks shown in the Table are to be provided: ● (6 x 12), O (6 x 24), and ◎ (6 x 37).

2 Length of chain cables may include shackles for connection.

23.1.2 Equipment Numbers

1. Equipment number is the value obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0hB + 0.1A$$

Where:

W : Full load displacement (t)

h and A : Values specified in the following **(1), (2)** and **(3)**

(1) h is the value obtained from the following formula:

$$f + h'$$

f : Vertical distance (m), at the midship, from the designed maximum load line to the top of the uppermost continuous deck beam at side

h' : Height (m) from the uppermost continuous deck to the top of uppermost superstructures or deckhouses having a breadth greater than B /4.

In the calculation of h', sheer and trim may be ignored. Where a deckhouse having a breadth greater than B/4 is located above a deckhouse with a breadth of B/4 or less, the narrow deckhouse may be ignored.

(2) A is the value obtained from the following formula:

$$fL_1 + \Sigma h'' l$$

f : Value specified in **(1)**

L_1: Length (m) of ship specified in **15.2.1-1**

$\Sigma h'' l$: Sum of the products of the height h'' (m) and length l (m) of superstructures, deckhouses or trunks which are located above the uppermost continuous deck within L_1 and also have a breadth greater than B/4 and a height greater than 1.5 m

(3) In the application of **(1)** and **(2),** screens and bulwarks more than 1.5 m in height are to be regarded as parts of superstructures or deckhouses.

2. Notwithstanding **-1**, for tugs the equipment number is to be obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0\left(fB + \sum h'' b\right) + 0.1A$$

W, f and A : As specified in **-1** above

$\Sigma h'' b$: Sum of the products of the height h'' (m) and the breadth b (m) of each widest superstructure and deckhouse which have a breadth greater than B/4 and are located above the uppermost continuous deck

23.1.3 Anchors

1. The mass of individual anchors may vary by ±7% of the mass given in **Table 23.1**, 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*.

23.1.4 Chain Cables

Chain cables for anchors are to be stud link chains of Grade 1, 2 or 3, specified in **4.1 of Chapter 4, Part 5**. However, Grade 1 chains made of Class 1 chain bars (*KSBC31*) are not to be used in association with high holding power anchors.

23.1.5 Tow Lines and Mooring Lines

1. As for wire ropes and hemp ropes used as tow lines and mooring lines, the breaking test load specified in **Chapter 5 or 6, Part 5** is not to be less than the breaking load given in **Table 23.1** respectively.

2. For ships having the ratio *A/EN* above 0.9, the following number of ropes should be added to the number required by **Table 23.1** for mooring lines.

Where *A/ EN* is above 0.9 up to 1.1 : 1

Where *A/ EN* is above 1.1 up to 1.2 : 2

Where *A/ EN* is above 1.2 : 3

EN : Equipment number

A : Value specified in **23.1.2(2)**

3. Application of synthetic fibre ropes for tow lines or mooring lines is to be as deemed appropriate by the Society.

4. For mooring lines connected with powered winches where the rope is stored on the drum, steel cored wire ropes of suitable flexible construction may be used instead of fibre cored wire ropes subject to the approval by the Society.

5. The length of individual mooring lines may be reduced by up to 7% of the lengths given in **Table 23.1**, provided that the total length of the stipulated number of mooring lines is not less than that obtained from multiplying the length by the number given in **Table 23.1.**

23.1.6 Chain Lockers

1. Chain lockers including spurling pipes are to be watertight up to the weather deck and to be provided with a means for drainage.

2. Chain lockers are to be subdivided by centre line screen walls.

3. Where a means of access is provided, it is to be closed by a substantial cover and secured by closely spaced bolts.

4. Spurling pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize water ingress.

23.1.7 Miscellaneous

1. All ships are to be provided with suitable appliances for handling anchors.

2. The inboard end of the chain cable is to be secured to the hull through a strong eye plate by means of a shackle or by other equivalent means.

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 normal towing (hereinafter referred to as towing fittings) and normal mooring (hereinafter referred to as mooring fittings), and their supporting hull structures (hereinafter referred to as supporting structures).

2. Ships are to be adequately provided with towing and mooring fittings.

3. The scantlings of supporting structures are to be built at least with the gross scantlings obtained by adding the corrosion addition specified in **23.2.2.-5** and **23.2.3.-5** to the net scantlings obtained by applying the criteria specified in this section.

4. The scantlings of supporting structures are to be in accordance with the relevant chapters or sections in addition to this section.

23.2.2 Towing Fittings

1. Arrangement of Towing Fittings

(1) Towing fittings are to be located on longitudinals, beams or girders, which are parts of the deck construction so as to facilitate efficient distribution of the towing load.

(2) When towing fittings cannot be located as specified in **(1),** towing fittings are to be arranged on reinforced members.

2. Design Load

Design load for towing fittings and their supporting structures (hereinafter referred to as “design load on fittings” (see **Fig.23.1**) in this paragraph) are to be as specified in **(1)** to **(6)** below:

(1) For normal towing operations (e.g. harbour/manouvring), the design load on the line (see **Fig.23.1**) is to be 1.25 times the intended maximum towing load.

(2) For other types of towing (e.g. escort), the design load on the line (see **Fig.23.1**) is to be the breaking strength of the towing line specified in **Table 23.1** according to the equipment number determined in **23.1.2**.

(3) The design load on fittings is to take into account all acting load.

(4) The point where the towing force acts on towing fittings is to be taken as the attachment point of the towing line.

(5) The design load on fittings is to take into account the total design load on the line specified in **(1)** and **(2)** (see **Fig.23.1**), but need not exceed twice the design load on the line.

(6) If the design load on fitting specified in **(2)** to **(5)** is less than the intended towing load stipulated in the construction specifications for the towing fittings and their supporting structures used for towing operations specified in **(2),** the design load on fittings is to be not less than the intended towing load.

3. Selection of Towing Fittings

Towing fittings are generally to be specified according to standards approved by the Society.

4. Allowable Stresses of Supporting Structures

Allowable stresses of supporting structures are not to be more than below:

(1) Normal stress : 100% of the specified yield point for the material used

(2) Shearing stress : 60% of the specified yield point for the material used

5. Corrosion Addition of Supporting Structures

For the corrosion addition of supporting structures, the value will be considered by the Society, but is not to be less than 2*mm*.

6. Safe Working Load (*SWL*)

(1) For towing fittings and their supporting structures used for towing operations specified in **-2(1),** the SWL is not to exceed 80% of the design load on fittings specified in **-2(1), (3), (4)** and **(5).**

(2) For towing fittings and their supporting structures used for towing operation specified in **-2(2),** the *SWL* is not to exceed the design load on fittings specified in **-2(2)** to **(6).**

(3) For towing fittings and their supporting structures used for towing operations specified in both **-2(1)** and **-2(2),** the *SWL* is not to exceed the greater of the design loads.

(4) The *SWL* of each fitting is to be marked by weld beads or equivalent on the fitting.

23.2.3 Mooring Fittings

1. Arrangement of Mooring Fittings

(1) Mooring fittings are to be located on longitudinals, beams or girders, which are parts of the deck construction so as to facilitate efficient distribution of the mooring load.

(2) When mooring fittings cannot be located as specified in **(1),** the mooring fittings are to be arranged on reinforced members.

2. Design Load

Design load for mooring fittings and their supporting structures (hereinafter referred to as design load on fittings (see **Fig.23.1**) in this paragraph) are to be as specified in **(1)** to **(7)** below:

(1) The design load on the line (see **Fig.23.1**) is to be 1.25 times the breaking strength of the mooring line specified in **Fig.23.1** according to the equipment number determined in **23.1.2**.

(2) The design load on fittings is to take into account all acting loads.

(3) The point where the mooring force acts on mooring fittings is to be taken as the attachment point of the mooring line.

(4) The design load on fittings is to take into account the total design load on the line specified in **(1)** (see **Fig.23.1**), but need not exceed twice the design load on the line.

(5) If the design load on fittings specified in **(1)** to **(4)** is less than 1.25 times the intended mooring load stipulated in the construction specifications for the mooring fittings and their supporting structures used for mooring operations specified in **(1),** the design load on the fittings is to be at least 1.25 times the intended mooring load.

(6) The design load applied to supporting hull structures for mooring winches is to be 1.25 times the intended maximum brake holding load.

(7) The design load applied to supporting hull structures for capstans is to be 1.25 times the intended maximum hauling-in force.

3. Selection of Mooring Fittings

Mooring fittings are generally to be specified according to standards approved by the Society.

4. Allowable Stresses of Supporting Structures

Allowable stresses of supporting structure are not to be more than below:

(1) Normal stress: 100% of the specified yield point for the material used

(2) Shearing stress: 60% of the specified yield point for the material used

5. Corrosion Addition of Supporting Structures

For the corrosion addition of supporting structures, the value will be considered by the Society, but is not to be less than 2*mm*.

6. Safe Working Load (*SWL*)

(1) The *SWL* is not to exceed 80% of the design load on fittings specified in **-2(1)** to **(5)** or the design load specified in **-2(6)** or **(7)**.

(2) The *SWL* of each fitting, excluding mooring winches and capstan, is to be marked by weld beads or equivalent on the fitting.

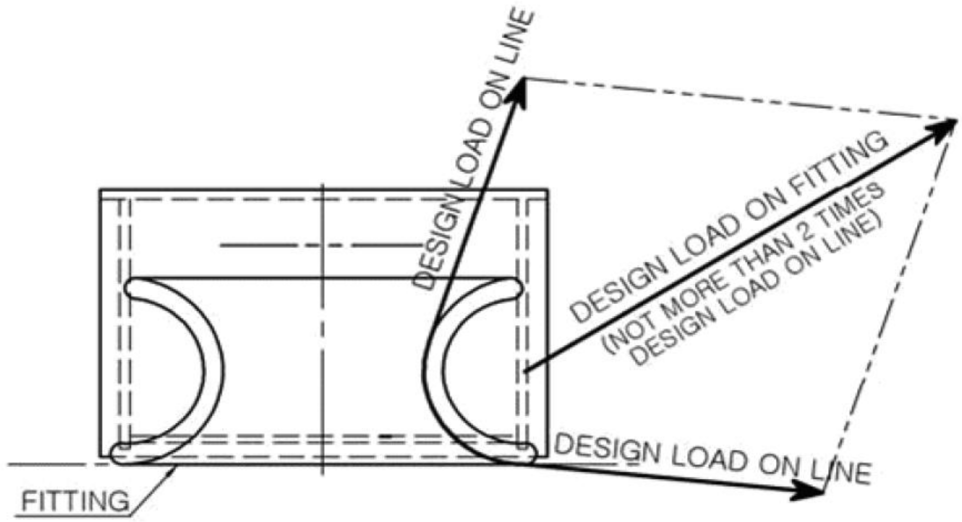
23.2.4 Towing and Mooring Fitting Arrangement Plan

Ships are to have a Towing and Mooring Fitting Arrangement Plan which includes the notes below:

(1) Approved standard and referenced No. of towing and mooring fittings

(2) For each towing and mooring fitting, location on the ship, purpose (mooring, harbour towing, escort towing etc.), *SWL* and manner of applying towing or mooring line load including limiting fleet angles.

Fig.23.1 Design Load



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.

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 $0.28MPa$ at 37.8°C 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 $0.28MPa$ at 37.8°C 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 7**, **Chapter 4 in Part 8**, and **Part 6** of the Rules 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°C, the preceding requirements may be suitably modified.

(3) Cofferdams specified in **(1)** may be used as pump rooms.

(4) 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 **4.2.4** and **4.3, Part 8** or machinery with a source of ignition is normally present. However, for oil tankers carrying cargo oil having a flash point above 60°C, 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:

$$t = 3.6S\sqrt{h} + 3.5 \quad (mm)$$

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 0.1D, and the thickness is not to be less than that obtained from the following formulae:

$t = 1.1S\sqrt{L} + 3.5 \quad (mm)$ for the lowermost plating

$t = 0.85S\sqrt{L} + 3.5 \quad (mm)$ 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:

$$t = 0.3S\sqrt{L + 150} + 3.5 \quad (mm)$$

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:

$$Z = 8.6Shl^2 \quad (cm^3)$$

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

$d + 0.44L - 0.54$

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 $0.15L$ 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:

$Z = 7CShl^2 \ \ (cm^3)$

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**

Where 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 24.1** according to the fixity condition of stiffener ends:

Table 24.1 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.13.1** **(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.13.1** **(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:

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

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 tranverse 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:

$Z = 7.13Sh^2 (cm^3)$

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:

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

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:

$d_0 = 0.15 l_0 (m)$

$Z = 8.7k^2 Shl_0^2 (cm^3)$

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:

$$d_0 = 0.16l_0(m)$$

$$Z = 9.7k^2(d + 0.026L)Sl_0^2\ (cm^3)$$

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.

24.10 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 $1m^2$ but does not exceed $2.5m^2$, 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 $2.5m^2$, 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 1B**, 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 **1.2.43 of Part 1A**.

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 under deck 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* x600 *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 center 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 27.1** 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 27.1 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 27.1** 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 **Chapter 28A, Part 2** 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 21.3** 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.

6. Ships not engaged on international voyages need not apply the provisions of **Chapter 28A** and **31.2, Part 2.**

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 23.1**.

3. Notwithstanding the provision in **-1**, for ships not engaged on international voyage Emergency Towing Procedures specified in **2.3, Part 5** **and** **23.3, Part 12** 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 27.2**.

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 **22.8, Part 2** and **21.8, Part 12** are not required.

Table 27.2 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 27.1** 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 27.1** 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 **Chapter 28A, Part 2** 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 21.3** 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.

6. Ships not engaged on international voyages need not to apply the provisions of **Chapter 28A** and **31.2, Part 2.**

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 27.2**.

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 23.1** 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 **22.8, Part 2 and 21.8, Part 12** are not required.

27.4 Ships not engaged on International Voyages

27.4.1 Relaxation to Ships not engaged on International Voyages

1. Ships not engaged on international voyages need not to apply the provisions of **31.2.2, Part 2**. Where deemed appropriate by the Society taking account of various conditions of such ships related to the navigation, the requirements of **31.2, Part 2** of the Rules need not to be applied to.

2. Bulk carriers not engaged on international voyages need not to apply the provisions of **32.2, Part 2**.

3. For non-conventional ships, the requirements in **2.2, Part 5** and **23.2** need not to be applied.

4. Ships not engaged on international voyages need not apply the provisions of **22.8, Part 2** and **21.8, Part 12.**

5. Ships not engaged on international voyages need not to apply the provisions of **2.4, Part 5** and **23.3, Part 12.**