RULES FOR BUILDING AND CLASSING

STEEL VESSELS UNDER 90 METERS (295 FEET) IN LENGTH 2018

NOTICE NO. 1 – JULY 2018

The following Rule Changes were approved by the ABS Rules Committee on 1 June 2018 and become **EFFECTIVE AS OF 1 JULY 2018.**

(See http://www.eagle.org for the consolidated version of the Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length, 2018, with all Notices and Corrigenda incorporated.)

Notes - The date in the parentheses means the date that the Rule becomes effective for new construction based on the contract date for construction, unless otherwise noted. (See 1-1-4/3.3 of the ABS Rules for Conditions of Classification (Part 1).)

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 2 HULL STRUCTURES AND ARRANGEMENTS

SECTION 1 LONGITUDINAL STRENGTH

7 Longitudinal Strength with Higher-Strength Materials

(Revise Paragraph 3-2-1/7.5, as follows:)

7.5 Hull Girder Section Modulus *(1 July 2018)*

When either the top or the bottom flange of the hull girder, or both, is constructed of higher-strength material, the section modulus, as obtained from 3-2-1/3.1 or 3-2-1/3.3.4, may be reduced by the factor Q.

$$SM_{hts} = Q(SM)$$

where

Q = 0.78 for Grade H32

Q = 0.72 for Grade H36

Q = 0.68[1] for H40 strength steel

H32, H36, H40 are as specified in Section 2-1-3 of the ABS *Rules for Materials and Welding (Part 2).*

Note:

1 The material factor for H40 may be taken as 0.66, provided that the hull structure is additionally verified for compliance with the requirements of:

- ABS *Guide for 'SafeHull-Dynamic Loading Approach' for Vessels*
- ABS *Guide for Spectral-Based Fatigue Analysis for Vessels*

Q factor for steels having other yield point or yield strength will be specially considered.

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 2 HULL STRUCTURES AND ARRANGEMENTS

SECTION 6 BEAMS, DECK GIRDERS, DECK TRANSVERSES, AND PILLARS

1 Beams

(Revise Paragraph 3-2-6/1.6 and add new 3-2-6/Figures 2, 3, and 4, as follows:)

1.6 Deck Fittings Support Structures *(1 July 2018)*

1.6.1 General

The strength of supporting hull structures in way of shipboard fittings used for mooring operations and/or towing operations as well as supporting hull structures of winches and capstans at the bow, sides and stern are to comply with the requirements of this section, where towing operations are defined as follows:

1.6.1(a) Normal Towing. Normal towing is the towing operations necessary for maneuvering in ports and sheltered waters associated with the normal operations of the vessel.

1.6.1(b) Other Towing. For vessels not subject to SOLAS Regulation II-1/3-4 Paragraph 1 but fitted with equipment for towing by another vessel or a tug (e.g., such as to assist the vessel in case of emergency as given in SOLAS Regulation II-1/3-4 Paragraph 2), the requirements designated as 'other towing' are to be applied to design and construction of those shipboard fittings and supporting hull structures.

The requirements of this section do not apply to design and construction of shipboard fittings and supporting hull structures used for special towing services, as follows:

- *Escort Towing.* Towing service, in particular, for laden oil tankers or LNG carriers, required in specific estuaries. Its main purpose is to control the vessel in case of failures of the propulsion or steering system. Reference should be made to local escort requirements and guidance given by, for example, the Oil Companies International Marine Forum (OCIMF).
- *Canal Transit Towing.* Towing service for vessels transiting canals (e.g., the Panama Canal). Reference should be made to local canal transit requirements.
- *Emergency Towing for Tankers.* Towing service to assist tankers in case of emergency. For the emergency towing arrangements, vessels subject to SOLAS regulation II-1/3-4 Paragraph 1 are to comply with that regulation and resolution MSC.35(63) as amended.

Shipboard fittings for mooring and/or towing, winches and capstans are to be located on stiffeners and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the mooring and/or towing load. The same attention is to be paid to recessed bitts, if fitted, of their structural arrangements and strength of supporting structures. Other arrangements may be accepted (for chocks in bulwarks, etc.) provided the strength is confirmed adequate for the intended service.

The requirements in this subsection are to be applied in conjunction with the requirements for mooring and towing equipment contained in Section 3-5-1.

1.6.2 Design Loads

Unless greater safe working load (SWL) and/or safe towing load (TOW) of shipboard fittings is specified by the applicant [see 3-2-6/1.6.2(c)], the minimum design load to be used is the greater values obtained from 3-2-6/1.6.2(a) or 3-2-6/1.6.2(b), whichever is applicable:

1.6.2(a) Mooring Operations. The minimum design load for shipboard fittings for mooring operations is the applicable value obtained from 3-2-6/1.6.2(a)i) or 3-2-6/1.6.2(a)ii):

i) *Mooring Line Force.* The minimum design load applied to supporting hull structures for shipboard fittings is to be 1.15 times the minimum breaking strength of the mooring line according to 3-5-1/Table 2. See Notes 1 and 2.

ii) *Mooring Winch and Capstan Force.* The minimum design load applied to supporting hull structures for winches is to be 1.25 times the intended maximum brake holding load, where the maximum brake holding load is to be assumed not less than 80% of the minimum breaking strength of the mooring line according to 3-5-1/Table 2. See Notes 1 and 2. For supporting hull structures of capstans, 1.25 times the maximum hauling-in force is to be taken as design load.

Notes:

1 If not otherwise specified by Section 3-5-1, side projected area including that of deck cargoes as given by the loading manual is to be taken into account for selection of mooring lines and the loads applied to shipboard fittings and supporting hull structure.

2 The increase of the minimum breaking strength for synthetic ropes according to 3-5-1/9.4 needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structure.

1.6.2(b) Towing Operations. The minimum design load for shipboard fittings for towing operations is the applicable value obtained from 3-2-6/1.6.2(b)i) through 3-2-6/1.6.2(b)iii), as applicable.

i) *Normal Towing Operations.* 1.25 times the intended maximum towing load (e.g., static bollard pull) as indicated on the towing and mooring arrangements plan.

ii) *Other Towing Service.* The minimum breaking strength of the tow line according to the 3-5-1/Table 3 for each equipment number (EN). EN is the corresponding value used for determination of the vessel's equipment. (See Notes 1 and 2)

Note: Side projected area including maximum stacks of deck cargoes is to be taken into account for assessment of lateral wind forces, arrangements of tug boats and selection of mooring lines.

Notes:

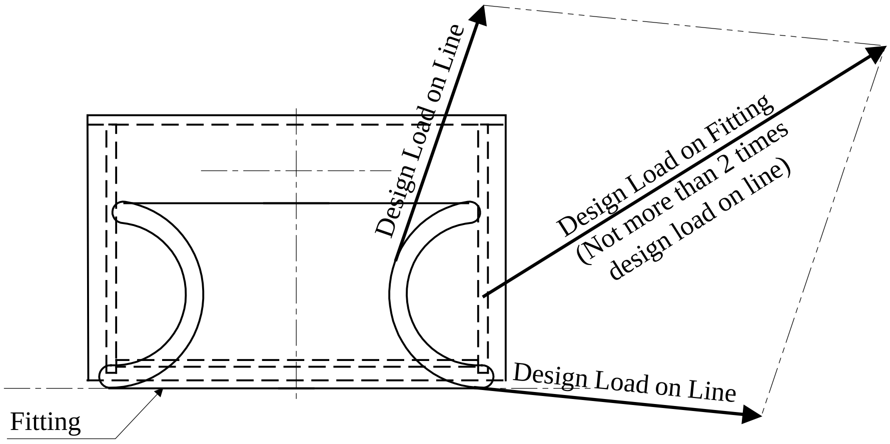
1 Side projected area including that of deck cargoes as given by the loading manual is to be taken into account for selection of towing lines and the loads applied to shipboard fittings and supporting hull structure.

2 The increase of the minimum breaking strength for synthetic ropes according to 3-5-1/17.7 needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structure.

iii) For fittings intended to be used for, both, normal and other towing operations, the greater of the design loads according to 3-2-6/1.6.2(b)i) and 3-2-6/1.6.2(b)ii).

1.6.2(c) Application of Design Loads. The design load is to be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting, the total design load applied to the fitting is equal to the resultant of the design loads acting on the line, see Figure 1 below. However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

FIGURE 1
Application of Design Loads *(2007)*



When a specific SWL is applied for a shipboard fitting at the request of the applicant, by which the design load will be greater than the above minimum values, the strength of the supporting hull structures is to be designed for an increased load in accordance with the appropriate SWL/design load relationship given by 3-2-6/1.6.2 and 3-5-1/19.5.1.

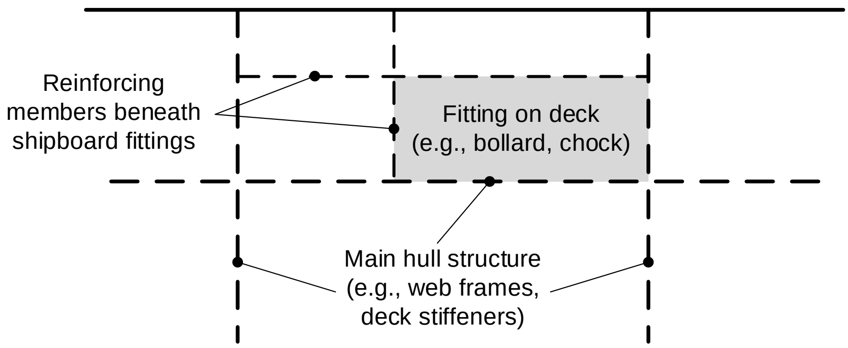
When a safe towing load, TOW, greater than that determined according to 3-5-1/19.5.2 is requested by the applicant, the design load is to be increased in accordance with the appropriate TOW/design load relationship given by 3-2-6/1.6.2 and 3-5-1/19.5.2.

1.6.3 Supporting Structures

1.6.3(a) Arrangement and Applied Design Load. The reinforced structural members (e.g., carling) are to be arranged beneath the deck where deck fittings are located and effectively distribute the loads from deck fittings for any variation of direction (horizontally and vertically).

The arrangement of reinforced members beneath shipboard fittings, winches, and capstans is to consider any variation of direction (horizontally and vertically) of the mooring forces acting upon the shipboard fittings, see 3-2-6/Figure 2 for a sample arrangement. Proper alignment of fitting and supporting hull structure is to be verified.

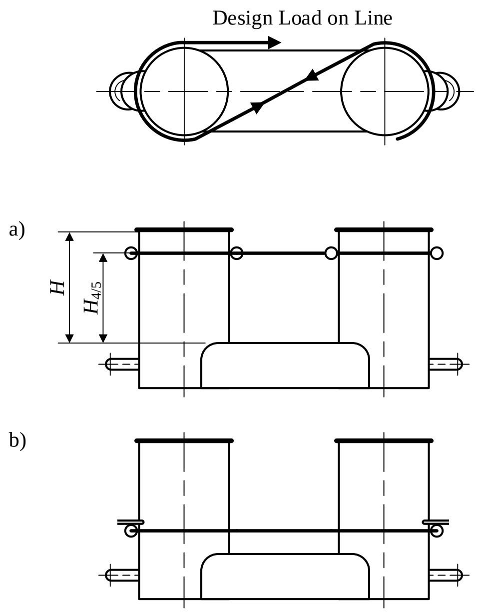
FIGURE 2
Sample Arrangement *(1 July 2018)*



1.6.3(b) Line Forces. The acting point of the mooring and/or towing force on shipboard fittings is to be taken at the attachment point of a mooring line or a towing line, as applicable and as described below.

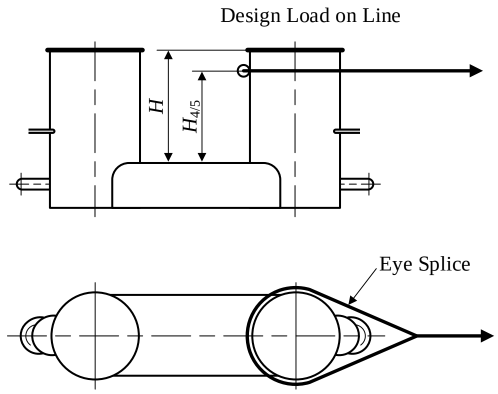
i) *Mooring Operations.* The acting point of the mooring force on shipboard fittings is to be taken at the attachment point of a mooring line or at a change in its direction. For bollards and bitts the attachment point of the mooring line is to be taken $^4/_5$ of the tube height above the base, see a) in 3-2-6/Figure 3 below. If fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins, see b) in 3-2-6/Figure 3 below.

FIGURE 3
Attachment Point of Mooring Line *(1 July 2018)*



ii) *Towing Operations.* The acting point of the towing force on shipboard fittings is to be taken at the attachment point of a towing line or at a change in its direction. For bollards and bitts the attachment point of the towing line is to be taken not less than $^4/_5$ of the tube height above the base, see 3-2-6/Figure 4 below.

FIGURE 4
Attachment Point of Towing Line *(1 July 2018)*



1.6.3(c) Allowable Stresses. Allowable stresses under the design load conditions as specified in 3-2-6/1.6.2 are as follows:

i) *For strength assessment with beam theory or grillage analysis:*

- Normal stress: 100% of the specified minimum yield point of the material;
- Shearing stress: 60% of the specified minimum yield point of the material;

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors being taken into account.

ii) *For strength assessment with finite element analysis:*

- Equivalent stress: 100% of the specified minimum yield point of the material.

For strength calculations by means of finite elements, the geometry is to be idealized as realistically as possible. The ratio of element length to width is not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges may be modelled by beam or truss elements. The element height of girder webs is not to exceed one-third of the web height. In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners may be modelled by using shell, plane stress, or beam elements. Stresses are to be read from the center of the individual element. For shell elements the stresses are to be evaluated at the mid plane of the element.

1.6.4 Scantlings

1.6.4(a) Net Scantlings. The net minimum scantlings of the supporting hull structure are to comply with the requirements given in 3-2-6/1.6.3. The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the above required minimum net scantlings. The required gross thicknesses are obtained by adding the total corrosion additions, t_c, given in 3-2-6/1.6.4(b) and, where applicable, the wear allowance, t_w, given in 3-2-6/1.6.4(c) to t_{net}.

1.6.4(b) Corrosion Addition. The corrosion addition, t_c, is not to be less than the following values:

- For the supporting hull structure, according to 7-A-4/Table 2 of the ABS *Rules for Survey After Construction (Part 7)* for the surrounding structure.
- For pedestals and foundations on deck which are not part of a fitting according to an accepted industry standard, 2.0 mm (0.08 in.).
- For shipboard fittings not selected from an accepted industry standard, 2.0 mm (0.08 in.).

1.6.4(c) Wear Allowance. In addition to the corrosion addition given in 3-2-6/1.6.4(b) the wear allowance, t_w, for shipboard fittings not selected from an accepted industry standard is not to be less than 1.0 mm (0.04 in.), added to surfaces which are intended to regularly contact the line.

(Renumber existing 3-2-6/Figure 2 as 3-2-6/Figure 5.)

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 2 HULL STRUCTURES AND ARRANGEMENTS

SECTION 12 PROTECTION OF DECK OPENINGS

5 Positions and Design Pressures *(1 January 2005)*

(Revise title of Paragraph 3-2-12/5.3, as follows:)

5.3 Vertical Weather Design Pressures *(1 July 2018)*

(Revise Subparagraph 3-2-12/5.3.2, as follows:)

5.3.2 Cargo Hatch Covers in Position 2

Where a position 2 hatchway is located at least one superstructure standard height higher than the freeboard deck, the design pressures are as follows:

$$p_V = 25.5 - 0.142(100 - L_f) \quad \text{kN/m}^2$$

$$= 2.6 - 0.0145(100 - L_f) \quad \text{tf/m}^2$$

$$= 0.238 - 0.00041(328 - L_f) \quad \text{Ltf/ft}^2$$

In 3-2-12/Figure 1, the positions 1 and 2 are illustrated for an example ship. Where an increased freeboard is assigned, the design pressures for hatch covers on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draft will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to the standard superstructure height h_N below the actual freeboard deck, see 3-2-12/Figure 2.

$$h_N = (1.05 + 0.01L_f) \quad \text{m}$$

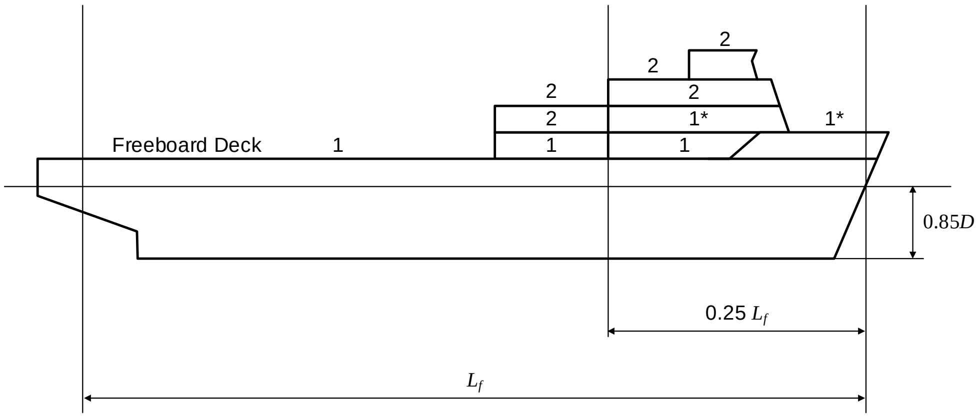
where $1.8 \text{ m} \le h_N \le 2.3 \text{ m}$

$$h_N = 3.281\,(1.05 + 0.0031L_f) \quad \text{ft}$$

where $5.91 \text{ ft} \le h_N \le 7.55 \text{ ft}$

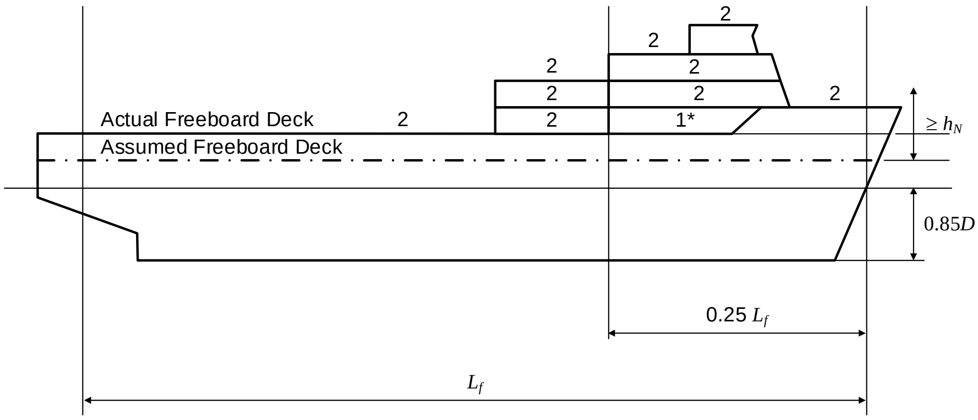
(Add new 3-2-12/Figures 1 and 2, as follows:)

FIGURE 1
Positions 1 and 2 *(1 July 2018)*



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck

FIGURE 2
Positions 1 and 2 for an Increased Freeboard *(1 July 2018)*



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck

(Add new Paragraph 3-2-12/5.5 and 3-2-12/Table 1, as follows:)

5.5 Horizontal Weather Design Pressures *(1 July 2018)*

The horizontal weather design pressure for determining the scantlings of outer edge girders (skirt plates) of weather deck hatch covers and of hatch coamings is:

$$p_H = a_H c_H R(b_H c_L f - z) \quad \text{kN/m}^2 \ (\text{tf/m}^2, \text{Ltf/ft}^2)$$

where

f	=	$0.04L + 4.1$	for L in meters
	=	$0.0122L + 4.1$	for L in feet

c_L = $\sqrt{0.011L}$ for L in meters

= $\sqrt{0.00336L}$ for L in feet

b_H = $1.0 + \left(\dfrac{\frac{x'}{L} - 0.45}{C_b + 0.2}\right)^2$ for $\frac{x'}{L} < 0.45$

= $1.0 + 1.5\left(\dfrac{\frac{x'}{L} - 0.45}{C_b + 0.2}\right)^2$ for $\frac{x'}{L} \geq 0.45$

a_H = $20 + \dfrac{e_H L_1}{12}$ for unprotected front coamings and hatch cover skirt plates

= $10 + \dfrac{e_H L_1}{12}$ 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 by at least one standard superstructure height h_N

= $5 + \dfrac{e_H L_1}{15}$ for side and protected front coamings and hatch cover skirt plates

= $7 + \dfrac{e_H L_1}{100} - 8 \cdot \dfrac{x'}{L}$ for aft ends of coamings and aft hatch cover skirt plates abaft amidships

= $5 + \dfrac{e_H L_1}{100} - 4 \cdot \dfrac{x'}{L}$ for aft ends of coamings and aft hatch cover skirt plates forward of amidships

L_1 = L

C_b = block coefficient, as defined in 3-1-1/13.3, where $0.6 \leq C_b \leq 0.8$. When determining scantlings of aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_b need not be taken less than 0.8.

x' = distance, in m (ft), between the transverse coaming or hatch cover skirt plate considered and aft end of the length L. When determining side coamings or side hatch cover skirt plates, the side is to be subdivided into parts of approximately equal length, not exceeding $0.15L$ each, and x' is to be taken as the distance between aft end of the length L and the center of each part considered.

z = vertical distance in m from the summer load line to the midpoint of stiffener span, or to the middle of the plate field

c_H = $0.3 + 0.7\dfrac{b'}{B'}$,where b'/B' is not to be taken less than 0.25

b' = breadth of coaming in m at the position considered

B' = actual maximum breadth of ship in m on the exposed weather deck at the position considered.

e_H = 1(1, 0.3048)

R = 1 (0.102, 0.0093), as defined in 3-2-12/5.3.1

L = length of vessel, as defined in 3-1-1/3.1, in m (ft)

The design load p_H is not to be taken less than the minimum values given in 3-2-12/Table 1.

TABLE 1
Minimum Design Load $p_{H\min}$ *(1 July 2018)*

L in m (ft)	*$p_{H\min}$ in kN/m^2 (tf/m^2, Ltf/ft^2) for*	
	Unprotected Fronts	*Elsewhere*
≤ 50 (164)	30 (3.06, 0.279)	15 (1.53, 0.139)
> 50 (164)	$R\left(25+\frac{e_H L}{10}\right)$	$R\left(12.5+\frac{e_H L}{20}\right)$

The horizontal weather design load need not be included in the direct strength calculation of the hatch cover, unless it is utilized for the design of substructures of horizontal supports according to the requirements of 3-2-12/11.23.2(c).

(Renumber existing 3-2-12/Table 1 as 3-2-12/Table 2.)

7 Hatchway Coamings, Companionway Sills and Access Sills

(Revise Paragraph 3-2-12/7.3, as follows:)

7.3 Coaming Plates *(1 July 2018)*

Where 3-2-12/11 is not applicable, coaming plates are not to be less in thickness than that obtained from the following equation:

$t = 0.05L + 7$ mm

$t = 0.0006L + 0.27$ in.

where

t = thickness, in mm (in.)

L = length of vessel, in m (ft), as defined in 3-1-1/3, but need not exceed 76 m (250 ft)

(Revise Subsection 3-2-12/11 and add 3-2-12/Figures 3 through 12 and 3-2-12/Tables 3 through 9, as follows:)

11 Hatchways Closed by Covers of Steel Fitted with Gaskets and Clamping Devices *(1 July 2018)*

These requirements apply to all ships except bulk carriers, ore carriers and combination carriers and are for all cargo hatch covers and coamings on exposed decks. Bulk carriers, ore carriers and combination carriers are to comply with the requirements in 5C-3-4/19 of the *Steel Vessel Rules*.

11.1 Strength of Covers

11.1.1 Stresses

The equivalent stress σ_e in steel hatch cover structures related to the net thickness shall not exceed 0.8Y, where Y is specified minimum upper yield point strength of the material in N/mm^2 (kgf/mm^2, psi). For design loads according to 3-2-12/5.5 and 3-2-12/11.9 to 3-2-12/11.13, the equivalent stress σ_e related to the net thickness shall not exceed 0.9Y when the stresses are assessed by means of FEM.

For grillage analysis, the equivalent stress may be taken as follows:

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \quad \text{N/mm}^2 \text{ (kgf/mm}^2\text{, psi)}$$

where

σ = normal stress, in N/mm^2 (kgf/mm^2, psi)

τ = shear stress, in N/mm^2 (kgf/mm^2, psi)

For FEM calculations, the equivalent stress may be taken as follows:

$$\sigma_e = \sqrt{\sigma_x{}^2 - \sigma_x \cdot \sigma_y + \sigma_y{}^2 + 3\tau^2} \quad \text{N/mm}^2 \text{ (kgf/mm}^2\text{, psi)}$$

where

σ_x = normal stress in *x*-direction, in N/mm^2 (kgf/mm^2, psi)

σ_y = normal stress in *y*-direction, in N/mm^2 (kgf/mm^2, psi)

τ = shear stress in the *x*-*y* plane in N/mm^2 (kgf/mm^2, psi)

Indices *x* and *y* are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell or plane strain elements, the stresses are to be read from the center of the individual element. It is to be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element center may lead to non-conservative results. Thus, a sufficiently fine mesh is to be applied in these cases or, the stress at the element edges shall not exceed the allowable stress. Where shell elements are used, the stresses are to be evaluated at the mid plane of the element.

The value for cargo hatch covers for bulk carriers, ore carriers and combination carriers is given in 5C-3-4/19.3.1(a) of the *Steel Vessel Rules*.

11.1.2 Deflection

The maximum vertical deflection of primary supporting members due to the vertical design load according to 3-2-12/5.3 is:

$$\delta_{vmax} = 0.0056\ell_g$$

where

ℓ_g = greatest span of primary supporting members

Where hatch covers are arranged for carrying containers and mixed stowage is allowed (i.e., a 40-foot container stowed on top of two 20-foot containers, particular attention should be paid to the deflections of hatch covers. Further the possible contact of deflected hatch covers within hold cargo has to be observed.

11.1.3 Material

Hatch covers and coamings are to be made of material in accordance with 3-1-2/Table 1 applying Class I requirements for top plate, bottom plate and primary supporting members.

The strength and stiffness of covers made of materials other than steel is to be equivalent to those of steel and is to be subject to special consideration.

11.1.4 General Requirements

Primary supporting members and secondary stiffeners of hatch covers are to be continuous over the breadth and length of hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to ensure sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed $^1/_3$ of the span of primary supporting members. When strength calculation is carried out by FE analysis using plane strain or shell elements, this requirement can be waived.

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

11.1.5 Net Scantling Approach

Unless otherwise quoted, the thicknesses t of the following sections are net thicknesses.

The net thicknesses are the member thicknesses necessary to obtain the minimum net scantlings required by 3-2-12/11.1 through 3-2-12/11.17 and 3-2.12/11.21.

The required gross thicknesses are obtained by adding corrosion additions, t_S, given in 3-2-12/Table 9.

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

11.3 Local Net Plate Thickness

The minimum local net plate thickness t of the hatch cover top plating is:

$$t = 15.8 F_p s \sqrt{\frac{p}{0.95Y}} \quad \text{mm}$$

$$t = 23.64 F_p s \sqrt{\frac{p}{0.95Y}} \quad \text{in.}$$

but not less than 1% of the spacing of the stiffener or 6 mm (0.24 in.) if that be greater.

where

F_p = factor for combined membrane and bending response

= 1.5 in general

= $2.375 \frac{\sigma}{Y}$ for $\frac{\sigma}{0.8Y} \geq 0.8$ for the attached plate flange of primary supporting members

s = stiffener spacing, in m (ft)

p = pressure p_V and p_L, as defined in 3-2-12/5.3 and 3-2-12/11.9.1, in kN/m^2 (tf/m^2, Ltf/ft^2)

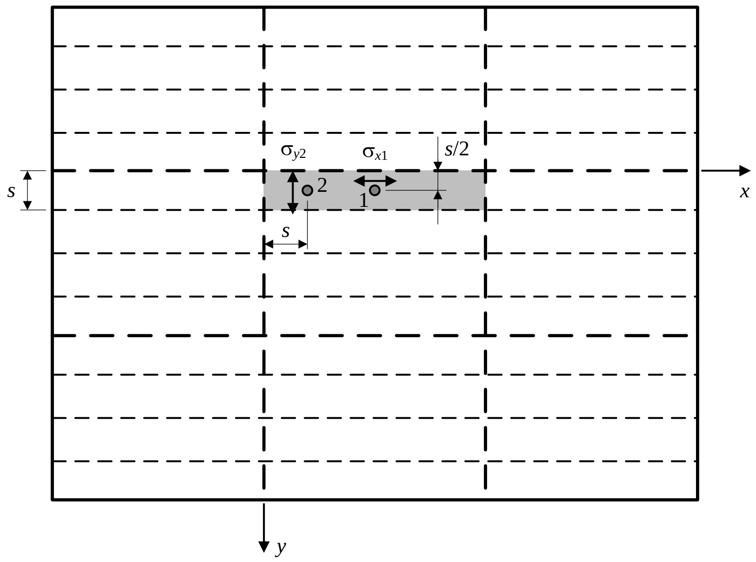
σ = maximum normal stress of hatch cover top plating, determined according to 3-2-12/Figure 3, N/mm^2 (kgf/mm^2, psi)

Y is as defined in 3-2-12/11.1

For flange plates under compression sufficient buckling strength according to 3-2-12/11.17 is to be demonstrated.

FIGURE 3
Determination of Normal Stress of the Hatch Cover Plating *(1 July 2018)*

$\sigma = \max[\sigma_{x1}\ (y = s/2);\ \sigma_{y2}\ (x = s)]$



11.3.1 Local Gross Plate Thickness of Hatch Covers for Wheel Loading

The local gross plate thickness of hatch covers subject to wheel loading is to be as given in, refer to 3-2-3/7.

Where the hatch cover is subject to other load as well, the hatch cover is to coupling with the applicable requirement in 3-2-12/11.

11.3.2 Lower Plating of Double Skin Hatch Covers and Box Girders

The thickness to fulfill the strength requirements is to be obtained from the calculation according to 3-2-15/9.15 under consideration of permissible stresses according to 3-2-12/11.1.1. When the lower plating is taken into account as a strength member of the hatch cover, the net thickness, in mm (in.), of lower plating is to be taken not less than 5 mm (0.20 in.).

When project cargo is intended to be carried on a hatch cover, the net thickness must not be less than:

$t = 6.5s$ mm

$= 0.078s$ in.

where s is as defined in 3-2-12/11.3

Project cargo means especially large or bulky cargo lashed to the hatch cover. Examples are parts of cranes or wind power stations, turbines, etc. Cargoes that can be considered as uniformly distributed over the hatch cover (e.g., timber, pipes or steel coils) need not to be considered as project cargo.

When the lower plating is not considered as a strength member of the hatch cover, the thickness of the lower plating will be specially considered.

11.5 Net Scantlings of Secondary Stiffeners

The net section modulus Z and net shear area A_s of uniformly loaded hatch cover stiffeners constrained at both ends must not be less than:

$$Z = \frac{104}{Y} s_s \ell_s^2 p \quad \text{cm}^3\text{, for design load according to 3-2-12/5.3}$$

$$= \frac{2793}{Y} s_s \ell_s^2 p \quad \text{in}^3$$

$$Z = \frac{93}{Y} s_s \ell_s^2 p \quad \text{cm}^3\text{, for design loads according to 3-2-12/11.9.1}$$

$$= \frac{2498}{Y} s_s \ell_s^2 p \quad \text{in}^3$$

$$A_s = \frac{10.8 s_s \ell_s p}{Y} \quad \text{cm}^2\text{, for design load according to 3-2-12/5.3}$$

$$= \frac{2418 s_s \ell_s p}{Y} \quad \text{in}^2$$

$$A_s = \frac{9.6 s_s \ell_s p}{Y} \quad \text{cm}^2\text{, for design load according to 3-2-12/11.9.1}$$

$$= \frac{2149 s_s \ell_s p}{Y} \quad \text{in}^2$$

where

ℓ_s = secondary stiffener span, to be taken as the spacing of primary supporting members or the distance between a primary supporting member and the edge support, in m (ft)

s_s = secondary stiffener spacing in m (ft)

Y is as defined in 3-2-12/11.1

p is as defined in 3-2-12/11.3

For secondary stiffeners of lower plating of double skin hatch covers, requirements mentioned above are not applied due to the absence of lateral loads.

The net thickness, in mm (in.), of the stiffener (except u-beams/trapeze stiffeners) web is to be taken not less than 4 mm (0.16 in.).

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

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_w is to be not greater than following equation:

$$\frac{h}{t_w} \leq 15k^{0.5}$$

where

h = height of the stiffener, in m (ft)

t_w = net thickness of the stiffener, in m (ft)

k = $235/Y$ ($23.963/Y$, $34084/Y$)

Y is as defined in 3-2-12/11.1

Stiffeners parallel to primary supporting members and arranged within the effective breadth according to 3-2-12/11.15.1 must be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members. It is to be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses according to 3-2-12/11.1.1. The requirements of this paragraph are not applied to stiffeners of lower plating of double skin hatch covers if the lower plating is not considered as strength member.

For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling according to 3-2-12/11.17.3 is to be verified.

For hatch covers subject to wheel loading or point loads stiffener scantlings are to be determined using the permissible stresses according to 3-2-12/11.1.1.

11.7 Net Scantlings of Primary Supporting Members

11.7.1 Primary Supporting Members

Scantlings of primary supporting members are obtained from calculations according to 3-2-12/11.15 under consideration of permissible stresses according to 3-2-12/11.1.1.

For all components of primary supporting members sufficient safety against buckling must be verified according to 3-2-12/11.17. For biaxial compressed flange plates this is to be verified within the effective widths according to 3-2-12/11.17.3(b).

The net thickness of webs of primary supporting members shall not be less than:

$$t = 6.5s \quad \text{mm}$$

$$= 0.078s \quad \text{in.}$$

but not less than 5 mm (0.20 in.)

where s is as defined in 3-2-12/11.3

11.7.2 Edge Girders (Skirt Plates)

Scantlings of edge girders are obtained from the calculations according to 3-2-12/11.15 under consideration of permissible stresses according to 3-2-12/11.1.1.

The net thickness of the outer edge girders exposed to wash of sea shall not be less than the largest of the following values:

$$t = 15.8s\sqrt{\frac{p_H}{0.95Y}} \quad \text{mm}$$

$$= 8.5s \quad \text{mm}$$

$$t = 23.652s\sqrt{\frac{p_H}{0.95Y}} \quad \text{in.}$$

$$= 0.102s \quad \text{in.}$$

but not less than 5 mm (0.20 in.)

where

p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.

s is as defined in 3-2-12/11.3.

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

$$I = uq\,s_{SD}^4 \quad \text{cm}^4 \ (\text{in}^4)$$

where

u = 6 (58.842, 7.693·10^{-3})

q = packing line pressure, in N/mm (kgf/mm, lbf/in). Minimum 5 N/mm (0.51 kgf/mm, 28.55 lbf/in)

s_{SD} = spacing of securing devices, in m (ft)

11.9 Cargo Loads

11.9.1 Distributed Loads

The load on hatch covers due to distributed cargo loads p_L resulting from heave and pitch (i.e., ship in the upright condition) is to be determined according to the following formula:

$$p_L = p_C(1 + a_a) \quad \text{kN/m}^2 \text{ (tf/m}^2\text{, Ltf/ft}^2\text{)}$$

where

p_C = uniform cargo load, in kN/m^2 (tf/m^2, Ltf/ft^2)

a_a = vertical acceleration addition

= $F_D m_D$

$$F_D = 0.11 \frac{v_0}{\sqrt{e_H L}}$$

$$m_D = m_0 - 5(m_0 - 1)\frac{x'}{L} \qquad \text{for } 0 \le \frac{x'}{L} \le 0.2$$

$$= 1.0 \qquad \text{for } 0.2 < \frac{x'}{L} \le 0.7$$

$$= 1 + \frac{m_0 + 1}{0.3}\left[\frac{x'}{L} - 0.7\right] \qquad \text{for } 0.7 < \frac{x'}{L} \le 1.0$$

m_0 = $1.5 + F_D$

v_0 = maximum speed at summer load line draft, in knots. v_0 is not to be taken less than $\sqrt{e_H L}$

e_H = 1 (1,0.3048)

x' = distance between the transverse coaming or hatch cover skirt plate considered and aft end of the length L, in m (ft)

L is as defined in 3-1-1/3.1.

11.9.2 Point Loads

The load due to a concentrated force P_S, except for container load, resulting from heave and pitch (i.e., ship in the upright condition) is to be determined as follows:

$$P_P = P_S(1 + a_a) \quad \text{kN (tf, Ltf)}$$

where

P_S = single force, in kN (tf, Ltf)

a_a is as defined in 3-2-12/11.9.1.

11.11 Container Loads

11.11.1 General

Where containers are stowed on hatch covers the load applied at each corner of a container stack and resulting from heave and pitch (i.e., ship in the upright condition) is to be determined as follows:

$$P = \frac{M}{4} \cdot (1 + a_a) \quad \text{kN (tf, Ltf)}$$

where

M = maximum designed weight of container stack in kN (tf, Ltf)

a_a is as defined in 3-2-12/11.9.1.

The loads applied at each corner of a container stack resulting from heave, pitch, and the vessel's rolling motion are to be considered are to be determined as follows, see also 3-2-12/Figure 4:

$$A_z = \frac{M}{2} \cdot (1 + a_a) \cdot \left(0.45 - 0.42 \frac{h_m}{f_P}\right) \quad \text{kN (tf, Ltf)}$$

$$B_z = \frac{M}{2} \cdot (1 + a_a) \cdot \left(0.45 + 0.42 \frac{h_m}{f_P}\right) \quad \text{kN (tf, Ltf)}$$

$$B_y = 0.24465M \quad \text{kN (tf, Ltf)}$$

where

A_z, B_z = support forces in z-direction at the forward and aft stack corners

B_y = support force in y-direction at the forward and aft stack corners

M = maximum designed weight of container stack, in kN (tf, Ltf)

h_m = designed height of center of gravity of stack above hatch cover top, in m (ft), may be calculated as weighted mean value of the stack, where the center of gravity of each tier is taken to be located at the center of each container

f_P = distance between foot points, in m (ft)

a_a is as defined in 3-2-12/11.9.1.

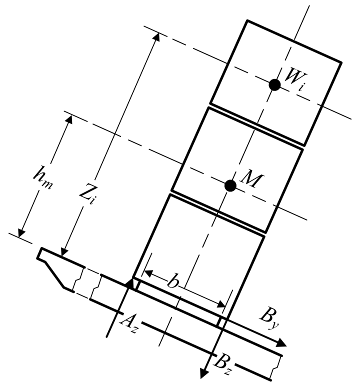
When strength of the hatch cover structure is assessed by grillage analysis according to 3-2-12/11.15, h_m and z_i need to be taken above the hatch cover supports. Force B_y does not need to be considered in this case.

Values of A_z and B_z applied for the assessment of hatch cover strength are to be shown in the drawings of the hatch covers.

It is recommended that container loads as calculated above are considered as limit for foot point loads of container stacks in the calculations of cargo securing (container lashing).

In the case of mixed stowage (20-foot and 40-foot container combined stack), the foot point forces at the fore and aft end of the hatch cover are not to be higher than resulting from the design stack weight for 40- foot containers, and the foot point forces at the middle of the cover are not to be higher than resulting from the design stack weight for 20-foot containers.

FIGURE 4
Forces due to Container Loads *(1 July 2018)*



11.11.2 Load Cases with Partial Loading

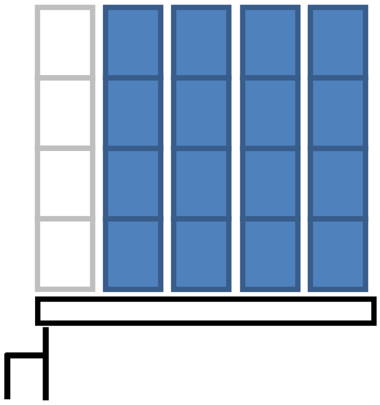
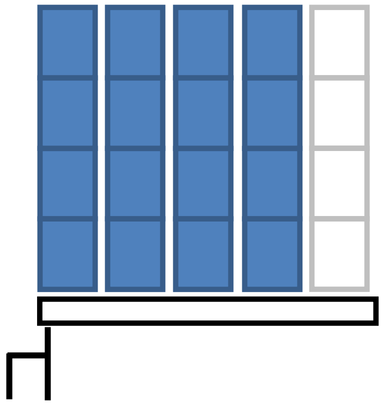
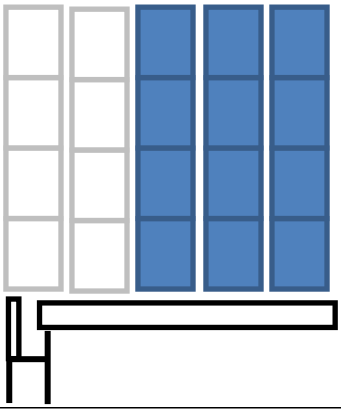
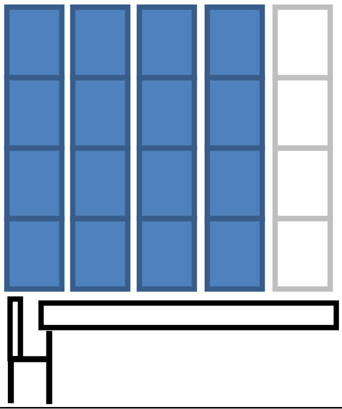
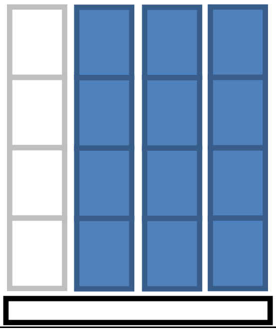
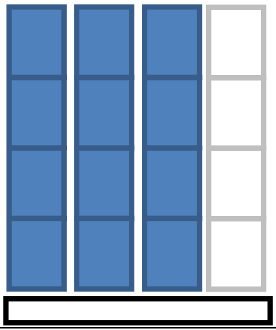
The load cases contained in 3-2-12/11.11.1 are also to be considered for partial non homogeneous loading which may occur in practice (e.g., where specified container stack places are empty). For each hatch cover, the heel directions, as shown in 3-2-12/Figure 5, are to be considered.

The load case "partial loading of container hatch covers" can be evaluated using a simplified approach, where the hatch cover is loaded without the outermost stacks that are located completely on the hatch cover. If there are additional stacks that are supported partially by the hatch cover and partially by container stanchions then the loads from these stacks are also to be neglected, see 3-2-12/Figure 5.

In addition, the case where only the stack places supported partially by the hatch cover and partially by container stanchions are left empty is to be assessed in order to consider the maximum loads in the vertical hatch cover supports.

Depending on the specific loading arrangements it may be necessary to consider additional partial load cases where more or different container stacks are left empty.

FIGURE 5
Partial Loading of a Container Hatch Cover *(1 July 2018)*

Heel Direction	←	→
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (center hatch covers)		

11.13 Loads due to Elastic Deformations of the Vessel's Hull

Hatch covers, which in addition to the loads according to 3-2-12/5.3 to 3-2-12/5.5 and 3-2-12/11.9 to 3-2-12/11.11 are loaded in the vessel's transverse direction by forces due to elastic deformations of the vessel's hull, are to be designed such that the sum of stresses does not exceed the permissible values given in 3-2-12/11.1.1.

11.15 Strength Calculations

Strength calculation for hatch covers may be carried out by either, grillage analysis or FEM. Double skin hatch covers or hatch covers with box girders are to be assessed using FEM, see 3-2-12/11.15.2.

11.15.1 Effective Cross-sectional Properties for Calculation by Grillage Analysis

Cross-sectional properties are to be determined considering the effective breadth. Cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth can be included, see 3-2-12/Figure 7.

The effective breadth of plating e_m of primary supporting members is to be determined according to 3-2-12/Table 3, considering the type of loading. Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

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

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 3-2-12/11.17.3(b).

TABLE 3
Effective Breadth e_m of Plating of Primary Supporting Members *(1 July 2018)*

ℓ/e	0	1	2	3	4	5	6	7	≥ 8
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

e_{m1} is to be applied where primary supporting members are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads

e_{m2} is to be applied where primary supporting members are loaded by 3 or less single loads

Intermediate values may be obtained by direct interpolation.

ℓ length of zero-points of bending moment curve:

$\ell = \ell_0$ for simply supported primary supporting members

$\ell = 0.6\ \ell_0$ for primary supporting members with both ends constraint,

where ℓ_0 is the unsupported length of the primary supporting member

e width of plating supported, measured from center to center of the adjacent unsupported fields

11.15.2 General Requirements for FEM Calculations

For strength calculations of hatch covers by means of finite elements, the cover geometry shall be idealized as realistically as possible. Element size must be appropriate to account for effective breadth. In no case element width shall be larger than stiffener spacing. In way of force transfer points and cutouts the mesh has to be refined where applicable. The ratio of element length to width shall not exceed 4.

The element height of webs of primary supporting member must not exceed one-third of the web height. Stiffeners, supporting plates against pressure loads, have to be included in the idealization. Stiffeners may be modeled by using shell elements, plane stress elements or beam elements. Buckling stiffeners may be disregarded for the stress calculation.

11.17 Buckling Strength of Hatch Cover Structures

For hatch cover structures sufficient buckling strength is to be demonstrated.

Definitions

a = length of the longer side of a single plate field (x-direction), in mm (in.)

b = breadth of the shorter side of a single plate field (y-direction), in mm (in.)

α_r = aspect ratio of single plate field

= a/b

n = number of single plate field breadths within the partial or total plate field

t = net plate thickness in mm (in.)

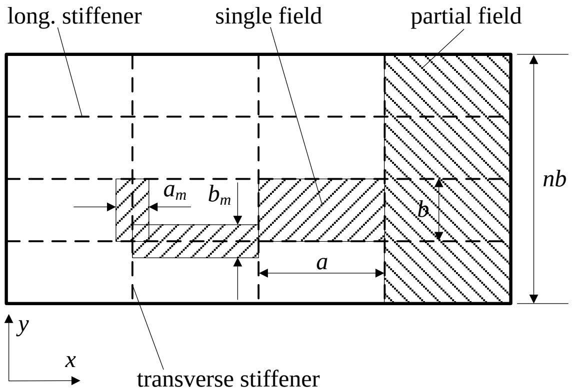
σ_{mx} = membrane stress in x-direction, in N/mm^2 (kgf/mm^2, psi)

σ_{my} = membrane stress in y-direction, in N/mm^2 (kgf/mm^2, psi)

τ = shear stress in the x-y plane, in N/mm^2 (kgf/mm^2, psi)

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

FIGURE 6
General Arrangement of Panel *(1 July 2018)*



longitudinal: stiffener in the direction of the length a
transverse: stiffener in the direction of the breadth b

If stresses in the x- and y-direction already contain the Poisson-effect (calculated using FEM), the following modified stress values may be used. Both stresses σ_x^* and σ_y^* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:

$$\sigma_{mx} = (\sigma_x^* - 0.3\sigma_y^*)/0.91$$

$$\sigma_{my} = (\sigma_y^* - 0.3\sigma_x^*)/0.91$$

where

σ_x^*, σ_y^* = stresses containing the Poisson-effect

Where compressive stress fulfills the condition $\sigma_y^* < 0.3\sigma_x^*$, then $\sigma_{my} = 0$ and $\sigma_{mx} = \sigma_x^*$

Where compressive stress fulfills the condition $\sigma_x^* < 0.3\,\sigma_y^*$, then $\sigma_{mx} = 0$ and $\sigma_{my} = \sigma_y^*$

The correction factor (F_1) for boundary condition at the longitudinal stiffeners is defined in 3-2-12/Table 4.

TABLE 4
Correction Factor F_1 *(1 July 2018)*

Stiffeners sniped at both ends	1.00
Guidance values[1] where both ends are effectively connected to adjacent structures	1.05 for flat bars 1.10 for bulb sections 1.20 for angle and tee-sections 1.30 for u-type sections[2] and girders of high rigidity
An average value of F_1 is to be used for plate panels having different edge stiffeners.	

Notes:

1 Exact values may be determined by direct calculations.

2 Higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA but not greater than 2.0.

σ_r = reference stress

= $0.9E\left(\frac{t}{b}\right)^2$, in N/mm^2 (kgf/mm^2, psi)

ψ = edge stress ratio taken equal to:

= σ_2/σ_1

σ_1 = maximum compressive stress, in N/mm^2 (kgf/mm^2, psi)

σ_2 = minimum compressive stress or tension stress, in N/mm^2 (kgf/mm^2, psi)

SF = safety factor (based on net scantling approach), taken equal to:

= 1.25 for hatch covers when subjected to the vertical design load according to 3-2-12/5.3

= 1.10 for hatch covers when subjected to loads according to 3-2-12/5.5 and 3-2-12/11.9 to 3-2-12/11.13

λ = reference degree of slenderness, taken equal to:

= $\sqrt{\frac{Y}{K\sigma_r}}$

K = buckling factor according to 3-2-12/Table 6

E = *2.06 x 10^5 N/mm^2 (21,000 kgf/mm^3, 30 x 10^6 psi)*

Y is as defined in 3-2-12/11.1.1.

11.17.1 Strength of Hatch Cover Plating

Each single plate field of the top and bottom plating of the hatch cover are to satisfy the following condition:

$$\left(\frac{|\sigma_{mx}|SF}{\kappa_x Y}\right)^{e1} + \left(\frac{|\sigma_{my}|SF}{\kappa_y Y}\right)^{e2} - B\left(\frac{\sigma_{mx}\sigma_{my}SF^2}{Y^2}\right) + \left(\frac{|\tau|SF\sqrt{3}}{\kappa_\tau Y}\right)^{e3} \le 1.0$$

The first two terms and the last term of the above condition shall not exceed 1.0.

The reduction factors κ_x, κ_y and κ_τ are given in 3-2-12/Table 5.

Where $\sigma_{mx} \le 0$ (tension stress), $\kappa_x = 1.0$.

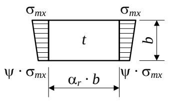
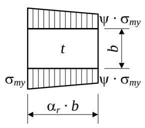
Where $\sigma_{my} \le 0$ (tension stress), $\kappa_y = 1.0$.

The exponents e_1, e_2, and e_3 as well as the factor B are to be taken as given in 3-2-12/Table 5.

TABLE 5
Coefficients e_1, e_2, e_3 and Factor B *(1 July 2018)*

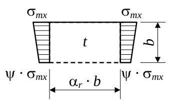
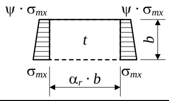
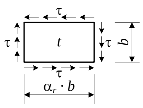
Exponents e_1 - e_3 and Factor B	*Plate Panel*
e_1	$1 + \kappa_x^4$
e_2	$1 + \kappa_y^4$
e_3	$1 + \kappa_x \kappa_y \kappa_\tau^2$
B σ_{mx} and σ_{my} positive (compression stress)	$(\kappa_x \kappa_y)^5$
B σ_{mx} or σ_{my} negative (tension stress)	1

TABLE 6
Buckling and Reduction Factors for Plane Elementary Plate Panels *(1 July 2018)*

Buckling Load Case	*Edge Stress Ratio ψ*	*Aspect Ratio $\alpha_r = a/b$*	*Buckling Factor K*	*Reduction Factor κ*
1 	$1 \ge \psi \ge 0$	$\alpha_r \ge 1$	$K = \dfrac{8.4}{\psi + 1.1}$	$\kappa_x = 1$ for $\lambda \le \lambda_c$ $\kappa_x = c\left(\dfrac{1}{\lambda} - \dfrac{0.22}{\lambda^2}\right)$ for $\lambda > \lambda_c$ $c = (1.25 - 0.12\psi) \le 1.25$ $\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$
	$0 \ge \psi \ge -1$		$K = 7.63 - \psi(6.26 - 10\psi)$	
	$\psi \le -1$		$K = 5.975(1 - \psi)^2$	
2 	$1 \ge \psi \ge 0$	$\alpha_r \ge 1$	$K = F_1\left(1 + \dfrac{1}{\alpha_r^2}\right)^2 \cdot \dfrac{2.1}{(\psi + 1.1)}$	$\kappa_y = c\left(\dfrac{1}{\lambda} - \dfrac{R + F^2(H - R)}{\lambda^2}\right)$ $c = (1.25 - 0.12\psi) \le 1.25$ $R = \lambda\left(1 - \dfrac{\lambda}{c}\right)$ for $\lambda < \lambda_c$ $R = 0.22$ for $\lambda \ge \lambda_c$ $\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$ $F = \left(1 - \dfrac{\dfrac{K}{0.91} - 1}{\lambda_p^2}\right) \cdot c_1 \ge 0$ $\lambda_p^2 = \lambda^2 - 0.5$ for $1 \le \lambda_p^2 \le 3$ $c_1 = \left(1 - \dfrac{F_1}{\alpha_r}\right) \ge 0$ $H = \lambda - \dfrac{2\lambda}{c\left(T + \sqrt{T^2 - 4}\right)} \ge R$ $T = \lambda + \dfrac{14}{15\lambda} + \dfrac{1}{3}$
	$0 \ge \psi \ge -1$	$1 \le \alpha_r \le 1.5$	$K = F_1\left[\left(1 + \dfrac{1}{\alpha_r^2}\right)^2 \cdot \dfrac{2.1(1 + \psi)}{1.1} - \dfrac{\psi}{\alpha_r^2}(13.9 - 10\psi)\right]$	
		$\alpha_r > 1.5$	$K = F_1\left[\left(1 + \dfrac{1}{\alpha_r^2}\right)^2 \cdot \dfrac{2.1(1 + \psi)}{1.1} - \dfrac{\psi}{\alpha_r^2}\left(5.87 - 1.87\alpha_r^2 + \dfrac{8.6}{\alpha_r^2} - 10\psi\right)\right]$	
	$\psi \le -1$	$1 \le \alpha_r \le \dfrac{3(1 - \psi)}{4}$	$K = 5.975F_1\left(\dfrac{1 - \psi}{\alpha_r}\right)^2$	
		$\alpha_r > \dfrac{3(1 - \psi)}{4}$	$K = F_1\left[3.9675\left(\dfrac{1 - \psi}{\alpha_r}\right)^2 + 0.5375\left(\dfrac{1 - \psi}{\alpha_r}\right)^4 + 1.87\right]$	

Explanations for boundary conditions
- - - - - plate edge free
——— plate edge simply supported

TABLE 6 (continued)
Buckling and Reduction Factors for Plane Elementary Plate Panels *(1 July 2018)*

Buckling Load Case	*Edge Stress Ratio* ψ	*Aspect Ratio* $\alpha_r = a/b$	*Buckling Factor K*	*Reduction Factor* κ
3 	$1 \geq \psi \geq 0$	$\alpha_r > 0$	$K = \dfrac{4\left(0.425 + \dfrac{1}{\alpha_r^2}\right)}{3\psi + 1}$	$\kappa_x = 1$ for $\lambda \leq 0.7$ $\kappa_x = \dfrac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
	$0 \geq \psi \geq -1$		$K = 4\left(0.425 + \dfrac{1}{\alpha_r^2}\right)(1 + \psi) - 5\psi(1 - 3.42\psi)$	
4 	$1 \geq \psi \geq -1$	$\alpha_r > 0$	$K = \left(0.425 + \dfrac{1}{\alpha_r^2}\right)\dfrac{3 - \psi}{2}$	
5 	-----	-----	$K = K_\tau \cdot \sqrt{3}$	$\kappa_\tau = 1$ for $\lambda \leq 0.84$ $\kappa_\tau = \dfrac{0.84}{\lambda}$ for $\lambda > 0.84$
		$\alpha_r \geq 1$	$K_\tau = \left[5.34 + \dfrac{4}{\alpha_r^2}\right]$	
		$0 < \alpha_r < 1$	$K_\tau = \left[4 + \dfrac{5.34}{\alpha_r^2}\right]$	
Explanations for boundary conditions	----- plate edge free ——— plate edge simply supported			

11.17.2 Webs and Flanges of Primary Supporting Members

For non-stiffened webs and flanges of primary supporting members sufficient buckling strength as for the hatch cover top and bottom plating is to be demonstrated according to 3-2-12/11.17.1.

11.17.3 Strength of Partial and Total Fields of Hatch Covers

11.17.3(a) Longitudinal and Transverse Secondary Stiffeners. It is to be demonstrated that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in 3-2-12/11.17.3(c) through 3-2-12/11.17.3(d).

For u-type stiffeners, the proof of torsional buckling strength according to 3-2-12/11.17.3(d) can be omitted.

Single-side welding is not permitted to use for secondary stiffeners except for u-stiffeners.

11.17.3(b) Effective Width of Hatch Cover Top and Bottom Plating. For demonstration of buckling strength according to 3-2-12/11.17.3(c) through 3-2-12/11.17.3(d) the effective width of plating may be determined by the following formulae:

$b_m = \kappa_x \cdot b$ for longitudinal stiffeners, in mm (in.)

$a_m = \kappa_y \cdot a$ for transverse stiffeners, in mm (in.)

where

a and b are as defined in 3-2-12/11.17.

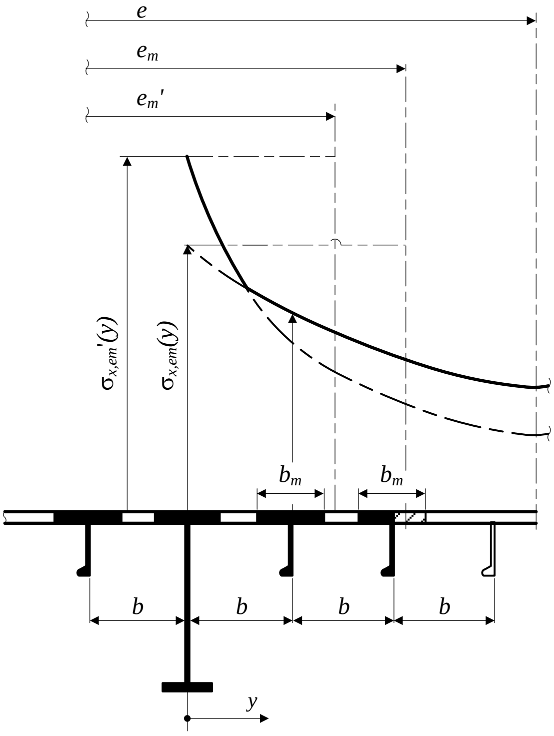
κ_x, κ_y are as defined in 3-2-12/11.17.1.

See also 3-2-12/Figure 6.

The effective width of plating is not to be taken greater than the value obtained from 3-2-12/11.15.1.

The effective width e'_m of stiffened flange plates of primary supporting members may be determined as follows:

FIGURE 7
Stiffening Parallel to Web of Primary Supporting Member *(1 July 2018)*



i) *Stiffening Parallel to Web of Primary Supporting Member*

$b < e_m$

$e'_m = nb_m$

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

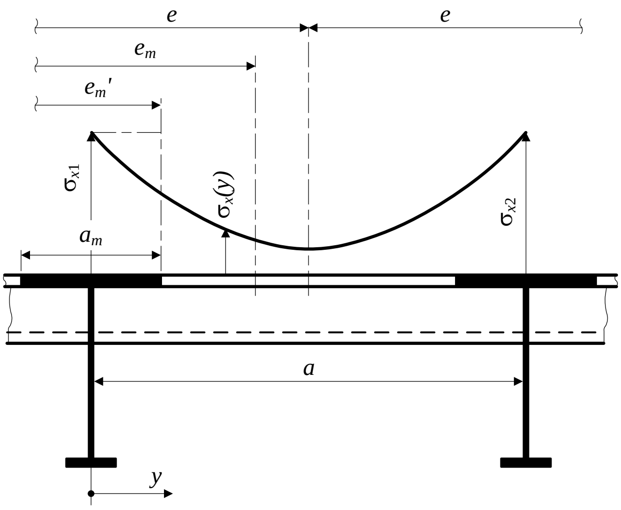
where

b_m = effective width of plating for transverse stiffeners, in mm (in.)

e and e_m are as defined in 3-2-12/11.15.

b and n are as defined in 3-2-12/11.17.

FIGURE 8
Stiffening Perpendicular to Web of Primary Supporting Member *(1 July 2018)*



ii) *Stiffening Perpendicular to Web of Primary Supporting Member*

$a \geq e_m$

$e'_m = na_m < e_m$

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

where

a_m = effective width of plating for longitudinal stiffeners, in mm (in.)

e and e_m are as defined in 3-2-12/11.15.

a and n are as defined in 3-2-12/11.17.

For $b \geq e_m$ or $a < e_m$, respectively, b and a have to be exchanged. a_m and b_m for flange plates are in general to be determined for $\psi = 1$.

Scantlings of plates and stiffeners are in general to be determined according to the maximum stresses $\sigma_{mx}(y)$ at webs of primary supporting member and stiffeners, respectively. For stiffeners with spacing b under compression arranged parallel to primary supporting members no value less than $0.25Y$ shall be inserted for $\sigma_{mx}(y = b)$.

The stress distribution between two primary supporting members can be obtained by the following formula:

$$\sigma_{mx}(y) = \sigma_{x1}\left\{1 - \frac{y}{e}\left[3 + c_1 - 4c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2)\right]\right\}$$

where

$c_1 = \dfrac{\sigma_{x2}}{\sigma_{x1}} \qquad 0 \leq c_1 \leq 1$

$c_2 = \dfrac{1.5}{e} \cdot \left(e''_{m1} + e''_{m2}\right) - 0.5$

e''_{m1} = proportionate effective breadth e_{m1} or proportionate effective width e'_{m1} of primary supporting member 1 within the distance *e*, as appropriate, in mm (in.)

e''_{m2} = proportionate effective breadth e_{m2} or proportionate effective width e'_{m2} of primary supporting member 2 within the distance *e*, as appropriate, in mm (in.)

σ_{x1}, σ_{x2} = normal stresses in flange plates of adjacent primary supporting member 1 and 2 with spacing *e*, based on cross-sectional properties considering the effective breadth or effective width, as appropriate, in N/mm^2 (kgf/mm^2, psi)

y = distance of considered location from primary supporting member 1, in mm (in.)

e is as defined in 3-2-13/11.15.

Shear stress distribution in the flange plates may be assumed linearly.

11.17.3(c) Lateral Buckling of Secondary Stiffeners.

$$\frac{\sigma_a + \sigma_b}{Y} SF \le 1$$

where

σ_a = uniformly distributed compressive stress in the direction of the stiffener axis

= σ_{mx} for longitudinal stiffeners, in N/mm^2 (kgf/mm^2, psi)

= σ_{my} for transverse stiffeners, in N/mm^2 (kgf/mm^2, psi)

σ_b = bending stress in the stiffener

= $\dfrac{M_0 + M_1}{Z_{st} \cdot 10^3}$, in N/mm^2 (kgf/mm^2)

= $998\left(\dfrac{M_0 + M_1}{Z_{st} \cdot 10^3}\right)$, in psi

M_0 = bending moment due to the deformation *w* of stiffener, taken equal to:

= $F_{Ki}\dfrac{p_z w}{c_f - p_z}$ with $(c_f - p_z) > 0$, in N-mm (kgf-mm, lbf-in)

M_1 = bending moment due to the lateral load p_l equal to:

= $\dfrac{p_\ell b a^2}{24 \cdot 10^3}$ for longitudinal stiffeners, in N-mm (kgf/mm)

= $\dfrac{15593 p_\ell b a^2}{24 \cdot 10^3}$ for longitudinal stiffeners, in lbf-in

= $\dfrac{p_\ell a (nb)^2}{c_s 8 \cdot 10^3}$ for transverse stiffeners, in N-mm (kgf/mm)

= $\dfrac{15593 p_\ell a (nb)^2}{c_s 8 \cdot 10^3}$ for transverse stiffeners, in lbf-in

n is as defined in 3-2-12/11.17, to be taken equal to 1 for ordinary transverse stiffeners.

p_ℓ = lateral load, in kN/m^2 (tf/m^2, Ltf/ft^2)

F_{Ki} = ideal buckling force of the stiffener

F_{Kix} = $\frac{\pi^2}{a^2} EI_x \cdot 10^4$ for longitudinal stiffeners, in N (kgf)

= $\frac{\pi^2}{a^2} EI_x$ for longitudinal stiffeners, in lbf

F_{Kiy} = $\frac{\pi^2}{(nb)^2} EI_y \cdot 10^4$ for transverse stiffeners, in N (kgf)

F_{Kiy} = $\frac{\pi^2}{(nb)^2} EI_y$ for transverse stiffeners, in lbf

I_x, I_y = net moments of inertia of the longitudinal or transverse stiffener including effective width of attached plating according to 3-2-12/11.17.3(b). I_x and I_y are to comply with the following criteria:

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

= $I_x \geq \frac{bt^3}{12}$ in^4

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

= $I_y \geq \frac{at^3}{12}$ in^4

p_z = nominal lateral load of the stiffener due to σ_x, σ_y and τ

p_{zx} = $\frac{t}{b}\left(\sigma_{xl}\left(\frac{\pi b}{a}\right)^2 + 2c_y\sigma_{my} + \sqrt{2}\tau_1\right)$ for longitudinal stiffeners, in N/mm^2 (kgf/mm^2, psi)

p_{zy} = $\frac{t}{a}\left(2c_x\sigma_{xl} + \sigma_{my}\left(\frac{\pi a}{nb}\right)^2\left(1+\frac{A_y}{at}\right) + \sqrt{2}\tau_1\right)$ for transverse stiffeners, in N/mm^2 (kgf/mm^2, psi)

σ_{xl} = $\sigma_{mx}\left(1+\frac{A_x}{bt}\right)$, in N/mm^2 (kgf/mm^2, psi)

c_x, c_y = factor taking into account the stresses perpendicular to the stiffener's axis and distributed variable along the stiffener's length

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

= $\frac{0.5}{1-\Psi}$ for $\Psi \leq 0$

A_x, A_y = net sectional area of the longitudinal or transverse stiffener, respectively, without attached plating, in mm^2 (in^2)

τ_1 = $\left[\tau - t\sqrt{YE\left(\frac{m_1}{a^2}+\frac{m_2}{b^2}\right)}\right] \geq 0$, in N/mm^2 (kgf/mm^2, psi)

for longitudinal stiffeners:

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

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

for transverse stiffeners:

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

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

w = $w_0 + w_1$, in mm (in.)

w_0 = assumed imperfection. For stiffeners sniped at both ends, w_0 must not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

$w_{0x} \leq \min\left(\frac{a}{250}, \frac{b}{250}, 10\right)$ for longitudinal stiffeners, in mm

$w_{0x} \leq \min\left(\frac{a}{9.843}, \frac{b}{9.843}, 0.394\right)$ for longitudinal stiffeners, in inches

$w_{0y} \leq \min\left(\frac{a}{250}, \frac{nb}{250}, 10\right)$ for transverse stiffeners, in mm

$w_{0y} \leq \min\left(\frac{a}{9.843}, \frac{nb}{9.843}, 0.394\right)$ for transverse stiffeners, in inches

w_1 = deformation of stiffener at midpoint of stiffener span due to lateral load p_ℓ. In case of uniformly distributed load the following values for w_1 may be used:

= $\frac{p_\ell b a^4}{384 \cdot 10^7 \cdot EI_x}$ for longitudinal stiffeners, in mm

= $\frac{1550 p_\ell b a^4}{384 \cdot 10^2 \cdot EI_x}$ for longitudinal stiffeners, in inches

= $\frac{5ap_\ell (nb)^4}{384 \cdot 10^7 \cdot EI_y c_s^2}$ for transverse stiffeners, in mm

= $\frac{775ap_\ell (nb)^4}{3840 \cdot EI_y c_s^2}$ for transverse stiffeners, in inches

c_f = elastic support provided by the stiffener *i) For longitudinal stiffeners:*

c_{fx} = $F_{Kix}\dfrac{\pi^2}{a^2}(1 + c_{px})$, in N/mm^2 (kgf/mm^2, psi)

c_{px} = $\dfrac{1}{1+\dfrac{0.91\left(\dfrac{12\cdot 10^4 I_x}{t^3 b}-1\right)}{c_{xa}}}$, in N/mm^2 (kgf/mm^2)

c_{px} = $\dfrac{1}{1+\dfrac{0.91\left(\dfrac{12\cdot I_x}{t^3 b}-1\right)}{c_{xa}}}$, in psi

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

= $\left[1+\left(\dfrac{a}{2b}\right)^2\right]^2$ for $a < 2b$

ii) For transverse stiffeners:

c_{fy} = $c_S F_{Kiy}\dfrac{\pi^2}{(nb)^2}(1 + c_{py})$, in N/mm^2 (kgf/mm^2, psi)

c_{py} = $\dfrac{1}{1+\dfrac{0.91\left(\dfrac{12\cdot 10^4 I_y}{t^3 a}-1\right)}{c_{ya}}}$, in N/mm^2 (kgf/mm^2)

c_{py} = $\dfrac{1}{1+\dfrac{0.91\left(\dfrac{12 I_y}{t^3 a}-1\right)}{c_{ya}}}$, in psi

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

= $\left[1+\left(\dfrac{nb}{2a}\right)^2\right]^2$ for $nb < 2a$

c_s = factor accounting for the boundary conditions of the transverse stiffener

= 1.0 for simply supported stiffeners

= 2.0 for partially constraint stiffeners

Z_{st} = net section modulus of stiffener (long. or transverse) including effective width of plating according to 3-2-12/11.17.3(b), in cm^3 (in^3)

E = *2.06 x 10^5 N/mm^2 (21,000 kgf/mm^3, 30 x 10^6 psi)*

Ψ, σ_{mx}, σ_{my}, τ, *SF*, *t*, *a*, and *b* are as defined in 3-2-12/11.17,

Y is as defined in 3-2-12/11.1.1,

If no lateral load p is acting, the bending stress σ_b is to be calculated at the midpoint of the stiffener span for the flange which results in the largest stress value. If a lateral load p is acting, the stress calculation is to be carried out for both flanges of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

11.17.3(d) Torsional Buckling of Secondary Stiffeners.

i) *Longitudinal Secondary Stiffeners.* The longitudinal ordinary stiffeners are to comply with the following criteria:

$$\frac{\sigma_{mx} SF}{\kappa_T Y} \le 1.0$$

where

κ_T = coefficient taken equal to:

= 1.0 for $\lambda_T \le 0.2$

$$= \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda_T^2}} \quad \text{for } \lambda_T > 0.2$$

Φ = $0.5[1 + 0.21(\lambda_T - 0.2) + \lambda_T^2]$

λ_T = reference degree of slenderness taken equal to:

$$= \sqrt{\frac{Y}{\sigma_{KiT}}}$$

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

$$= \frac{E}{100 I_P}\left(\frac{\pi^2 I_\omega 10^2}{a^2}\varepsilon + 0.385 I_T\right), \text{ in psi}$$

For I_p, I_T, I_ω see 3-2-12/Figure 9 and 3-2-12/Table 7.

I_p = net polar moment of inertia of the stiffener related to the point C, in cm^4 (in^4)

I_T = net St. Venant's moment of inertia of the stiffener, in cm^4 (in^4)

I_ω = net sectional moment of inertia of the stiffener related to the point C, in cm^6 (in^6)

ε = degree of fixation taken equal to:

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

where I_ω in cm^6 and b, t, h_w, and t_w in mm

$$= 1 + \sqrt{\frac{a^4}{\frac{3}{4}\pi^4 I_\omega\left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

where I_ω in in^6 and b, t, h_w, and t_w in inches

h_w = web height, in mm (in.)

t_w = net web thickness, in mm (in.)

b_f = flange breadth, in mm (in.)

t_f = net flange thickness, in mm (in.)

A_w = net web area

= $h_w t_w$, in mm^2 (in^2)

A_f = net flange area

= $b_f t_f$, in mm^2 (in^2)

e_f = $h_w + \dfrac{t_f}{2}$, in mm (in.)

E = *2.06 x 10^5 N/mm^2 (21,000 kgf/mm^2, 30 x 10^6 psi)*

SF, σ_{mx}, *a*, and *b* are as defined in 3-2-12/11.17.

Y is as defined in 3-2-12/11.1.1.

ii) *Transverse Secondary Stiffeners.* For transverse secondary stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, sufficient torsional buckling strength is to be demonstrated in accordance with 3-2-12/11.17.3(d)i).

FIGURE 9
Dimensions of Stiffeners *(1 July 2018)*

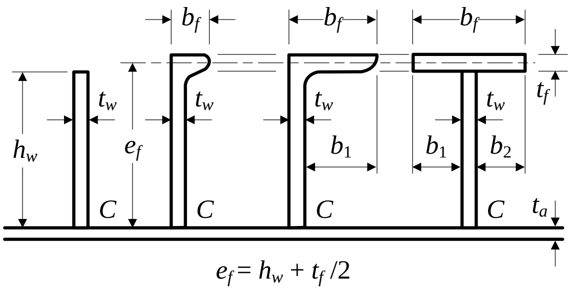


TABLE 7
Moments of Inertia *(1 July 2018)*

Section	I_P	I_T	I_ω
Flat bar	$\dfrac{h_w^3 \cdot t_w}{3 \cdot i_m}$	$\dfrac{h_w \cdot t_w^3}{3 \cdot i_m}\left(1 - 0.63\dfrac{t_w}{h_w}\right)$	$\dfrac{h_w^3 \cdot t_w^3}{36 \cdot j_m}$
Sections with bulb or flange	$\dfrac{1}{i_m}\left(\dfrac{A_w \cdot h_w^2}{3} + A_f \cdot e_f^2\right)$	$\dfrac{h_w \cdot t_w^3}{3 \cdot i_m}\left(1 - 0.63\dfrac{t_w}{h_w}\right)$ + $\dfrac{b_f \cdot t_f^3}{3 \cdot i_m}\left(1 - 0.63\dfrac{t_f}{b_f}\right)$	for bulb and angle sections: $\dfrac{A_f \cdot e_f^2 \cdot b_f^2}{12 \cdot j_m}\left(\dfrac{A_f + 2.6A_W}{A_f + A_W}\right)$ for tee-sections: $\dfrac{b_f^3 \cdot t_f \cdot e_f^2}{12 \cdot j_m}$
i_m is 10^4 for cm^4 and 1 for in^4 j_m is 10^6 for cm^6 and 1 for in^6			

11.19 Details of Hatch Covers

11.19.1 Container Foundations on Hatch Covers

The substructures of container foundations are to be designed for cargo and container loads according to 3-2-12/4.3 through 3-2-12/5.5 and 3-2-12/11.9 through 3-2-12/11.11 applying the permissible stresses according to 3-2-12/11.1.1.

11.19.2 Weathertightness

11.19.2(a) Packing Material (General). The packing material is to be suitable for all expected service conditions of the ship and is to be compatible with the cargoes to be transported. The packing material is to be selected with regard to dimensions and elasticity in such a way that expected deformations can be carried. Forces are to be carried by the steel structure only.

The packing is to be compressed so as to give the necessary tightness effect for all expected operating conditions. Special consideration shall be given to the packing arrangement in ships with large relative movements between hatch covers and coamings or between hatch cover sections.

11.19.2(b) Dispensation of Weathertight Gaskets. For hatch covers of cargo holds solely for the transport of containers, upon request by the owners and subject to compliance with the following conditions the fitting of weathertight gaskets according to 3-2-12/11.19.2(a) may be dispensed with:

- The hatchway coamings shall be not less than 600 mm (23.622 in.) in height.
- The exposed deck on which the hatch covers are located is situated above a depth $H(x)$. $H(x)$ is to be shown to comply with the following criteria:

  $H(x) \geq d + f_b + h$ m (ft)

  where

  f_b = minimum required freeboard for the vessel, in m (ft)

h = 4.6 m (15.09 ft) for $\dfrac{x}{L_f} \le 0.75$

= 6.9 m (22.64 ft) for $\dfrac{x}{L_f} > 0.75$

L is as defined in 3-1-1/3.1.

L_f is as defined in 3-1-1/3.3.

d is as defined in 3-1-1/9.

- Labyrinths, gutter bars or equivalents are to be fitted proximate to the edges of each panel in way of the coamings. The clear profile of these openings is to be kept as small as possible.
- Where a hatch is covered by several hatch cover panels the clear opening of the gap in between the panels shall be not wider than 50 mm. (2.0 in.)
- The labyrinths and gaps between hatch cover panels shall be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.
- Cargo holds and fire-fighting systems are to be provided with an efficient bilge pumping system.
- Bilge alarms are to be provided in each hold fitted with non-weathertight covers.
- Furthermore, Section 3, Stowage and Segregation of Cargo Transport Units Containers Containing Dangerous Goods, of IMO MSC/Circ.1087 Guidelines for Partially Weathertight Hatchway Covers On Board Containerships is recommended concerning the stowage and segregation of containers containing dangerous goods.

11.19.2(c) Drainage Arrangements. Cross-joints of multi-panel covers are to be provided with efficient drainage arrangements.

11.21 Hatch Coaming Strength Criteria

11.21.1 Local Net Plate Thickness of Coamings

The net thickness of weather deck hatch coamings shall not be less than the larger of the following values:

$$t = 14.2s\sqrt{\frac{p_H}{0.95Y}} \quad \text{mm}$$

$$= 21.26s\sqrt{\frac{p_H}{0.95Y}} \quad \text{in.}$$

but not less than $6 + \dfrac{L_1}{100}$ mm $\left(0.236 + \dfrac{1.2L_1}{10000}\text{ in.}\right)$

where

L_1 = L, need not be taken greater than 300 m (958 ft)

s is as defined in 3-2-12/11.3.

p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.1.

Longitudinal strength aspects are to be observed.

11.21.2 Net Scantlings of Secondary Stiffeners of Coamings

The stiffeners must be continuous at the coaming stays. For stiffeners with both ends constraint the elastic net section modulus Z and net shear area A_S calculated on the basis of net thickness, must not be less than:

$$Z = \frac{83}{Y} s\ell_s^2 p_H \quad \text{cm}^3$$

$$= \frac{2230}{Y} s\ell_s^2 p_H \quad \text{in}^3$$

$$A_s = \frac{10 s\ell_s p_H}{Y} \quad \text{cm}^2$$

$$= \frac{2240 s\ell_s p_H}{Y} \quad \text{in}^2$$

where

ℓ_s = secondary stiffener span to be taken as the spacing of coaming stays, in m (ft)

s is as defined in 3-2-12/11.3.

p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.1.

For sniped stiffeners of coaming at hatch corners section modulus and shear area at the fixed support have to be increased by 35%. The gross thickness of the coaming plate at the sniped stiffener end shall not be less than:

$$t = 19.6\sqrt{\frac{p_H s(\ell - 0.5\, s)}{Y}} \quad \text{mm}$$

$$= 29.32\sqrt{\frac{p_H s(\ell - 0.5\, s)}{Y}} \quad \text{in.}$$

where

s is as defined in 3-2-12/11.3.

p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.1.

11.21.3 Coaming Stays

Coaming stays are to be designed for the loads transmitted through them and permissible stresses according to 3-2-12/11.1.1.

11.21.3(a) Coaming Stay Section Modulus. At the connection with deck, the net section modulus Z, in cm^3 (in^3) of the coaming stays designed as beams with flange (as shown in 3-2-12/Figure 10 a and b) shall not be less than:

$$Z = \frac{526}{Y} e_s h_s^2 p_H \quad \text{cm}^3$$

$$= \frac{14138}{Y} e_s h_s^2 p_H \quad \text{in}^3$$

where

e_s = spacing of coaming stays, in m (ft)

h_s = height of coaming stays of coamings where $h_s < 1.6$ m (5.25 ft), in m (ft)

p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.1.

Coaming stays are to be supported by appropriate substructures. Face plates may only be included in the calculation if an appropriate substructure is provided and welding ensures an adequate joint.

11.21.3(b) Web Thickness of Coaming Stays. At the connection with deck, the gross thickness t_w, in mm (in.), of the coaming stays designed as beams with flange (as shown in 3-2-12/Figure 10 a and b) shall not be less than:

$$t_w = \frac{2}{Y} \cdot \frac{e_s h_s p_H}{h_w} + t_s \quad \text{mm}$$

$$= \frac{373.34}{Y} \cdot \frac{e_s h_s p_H}{h_w} + t_s \quad \text{in.}$$

where

h_w = web height of coaming stay at its lower end, in m (ft)

t_s = corrosion addition according to 3-2-12/11.25, in mm (in.)

e_s and h_s are as defined in 3-2-12/11.21.3(a).

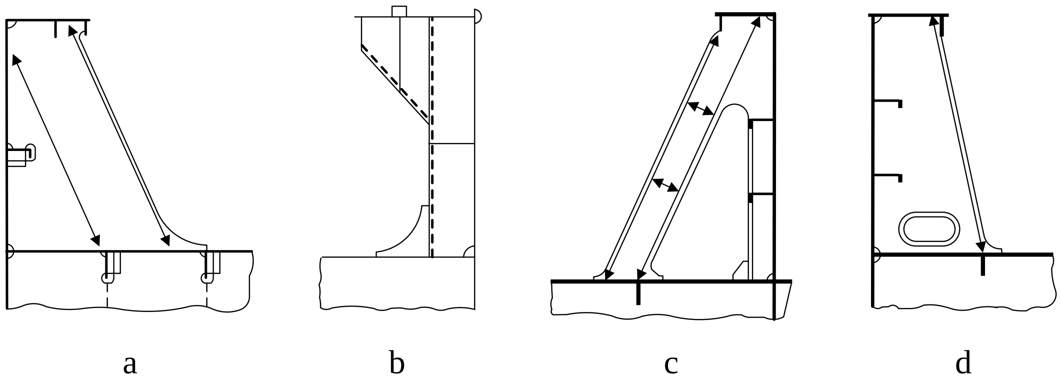
p_H is as defined in 3-2-12/5.5.

Y is as defined in 3-2-12/11.1.1.

For other designs of coaming stays, such as those shown in 3-2-12/Figure 10 c and d, the stresses are to be determined through a grillage analysis or FEM. The calculated stresses are to comply with the permissible stresses according to 3-2-12/11.1.1.

Webs are to be connected to the deck by fillet welds on both sides with a fillet weld throat thickness of at least $0.44t_w$.

FIGURE 10
Examples for Typical Coaming Stay Configurations *(1 July 2018)*



11.21.3(c) Coaming Stays Under Friction Load. For coaming stays, which transfer friction forces at hatch cover supports, fatigue strength is to be considered in the design.

11.21.4 Further Requirements for Hatch Coamings

11.21.4(a) Longitudinal Strength. Hatch coamings which are part of the longitudinal hull structure are to be designed according to the requirements for longitudinal strength (see also 3-2-12/7.9).

For structural members welded to coamings and for cutouts in the top of coamings sufficient fatigue strength is to be verified.

Longitudinal hatch coamings with a length exceeding 0.1*L* m (ft) 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 (11.81 in.) in length.

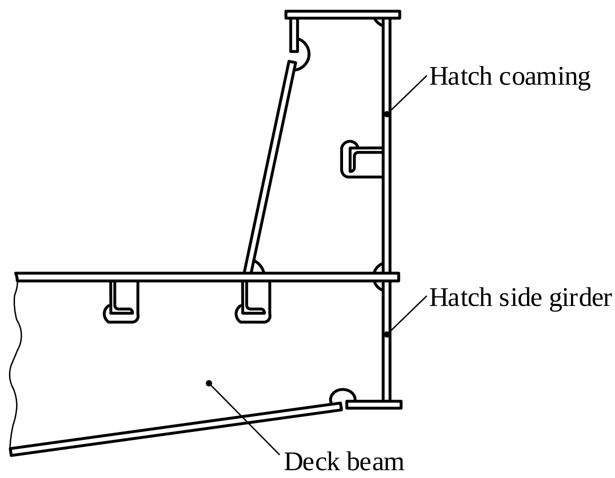
11.21.4(b) Local Details. Local details are to be adequate for the purpose of transferring the loads on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Structures under deck are to be checked against the load transmitted by the stays.

11.21.4(c) Stays. On ships carrying cargo on deck, such as timber, coal or coke, the stays are to be spaced not more than 1.5 m (5 ft) apart.

11.21.4(d) Extend of Coaming Plates. Coaming plates are to extend to the lower edge of the deck beams or hatch side girders are to be fitted that extend to the lower edge of the deck beams. Extended coaming plates and hatch side girders are to be flanged or fitted with face bars or half-round bars. 3-2-12/Figure 11 gives an example.

FIGURE 11
Example for Arrangement of Coaming Plates *(1 July 2018)*



11.21.4(e) Drainage Arrangement at the Coaming. If drain channels are provided inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming, drain openings are to be provided at appropriate positions of the drain channels.

Drain openings in hatch coamings are to be arranged with sufficient distance to areas of stress concentration (e.g., hatch corners, transitions to crane posts).

Drain openings are to be arranged at the ends of drain channels and are to be provided with non-return valves to prevent ingress of water from outside. It is unacceptable to connect fire hoses to the drain openings for this purpose.

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.

11.23 Closing Arrangements

11.23.1 Securing Devices

11.23.1(a) General. Securing devices between cover and coaming and at cross-joints are to be provided to ensure weathertightness. Sufficient packing line pressure is to be maintained.

Securing devices must be appropriate to bridge displacements between cover and coaming due to hull deformations.

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

Sufficient number of securing devices is to be provided at each side of the hatch cover considering the requirements of 3-2-12/11.7.2. This applies also to hatch covers consisting of several parts.

Specifications of the materials are to be shown in the drawings of the hatch covers.

11.23.1(b) Rod Cleats. Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

11.23.1(c) Hydraulic Cleats. 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.

11.23.1(d) Cross-sectional Area of the Securing Devices. The gross cross-sectional area of the securing devices is not to be less than:

$$A = q s_{SD} k_\ell \quad \text{cm}^2\ (\text{in}^2)$$

where

s_{SD} = spacing between securing devices as defined in 3-2-12/11.7.2, in m (ft), not to be taken less than 2 m (6.5 ft)

k_ℓ = $0.28\left(\frac{235}{Y}\right)^{e_\ell}$ where Y in N/mm^2

= $2.75\left(\frac{23.963}{Y}\right)^{e_\ell}$ where Y in kgf/mm^2

= $2.317 \cdot 10^{-3}\left(\frac{34084}{Y}\right)^{e_\ell}$ where Y in psi

Y = minimum yield strength of the material as defined in 3-2-12/11.1.1, in N/mm^2 (kgf/mm^2, psi), but is not to be taken greater than $0.7\sigma_m$

σ_m = tensile strength of the material, in N/mm^2 (kgf/mm^2, psi)

e_ℓ = 0.75 for $Y > 235$ N/mm^2 (23.963 kgf/mm^2, 34084 psi) $235/Y$ ($23.963/Y$, $34084/Y$)

= 1.00 for $Y \leq 235$ N/mm^2 (23.963 kgf/mm^2, 34084 psi)

q is as defined in 3-2-12/11.7.2.

Rods or bolts are to have a gross diameter not less than 19 mm (0.75 in.) for hatchways exceeding 5 m^2 (54 ft^2) in area.

Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to 3-2-12/11.23.1(e). As load the packing line pressure q multiplied by the spacing between securing devices s_{SD} is to be applied.

11.23.1(e) Anti Lifting Devices. The securing devices of hatch covers, on which cargo is to be lashed, are to be designed for the lifting forces resulting from loads according to 3-2.12/11.11, see 3-2-12/Figure 12. Unsymmetrical loadings, which may occur in practice, are to be considered. Under these loadings the equivalent stress in the securing devices is not to exceed:

$$\sigma_V = \frac{42}{k_\ell} \quad \text{N/mm}^2$$

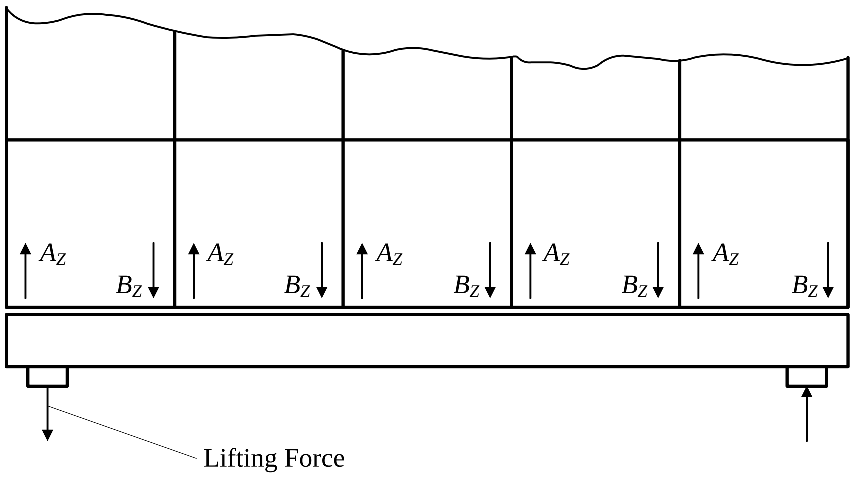
$$= \frac{42.08}{k_\ell} \quad \text{kgf/mm}^2$$

$$= \frac{50.41}{k_\ell} \quad \text{psi}$$

where k_ℓ is as defined in 3-2-12/11.23.1(d).

The partial load cases given in 3-2-12/Figure 5 may not cover all unsymmetrical loadings, critical for hatch cover lifting.

FIGURE 12
Lifting Forces at a Hatch Cover *(1 July 2018)*



11.23.2 Hatch Cover Supports, Stoppers and Supporting Structures

11.23.2(a) Horizontal Mass Forces. For the design of hatch cover supports the horizontal mass force is to be calculated:

$$F_h = m_h a_h \quad \text{N}$$

$$= 0.102 m_h a_h \quad \text{kgf}$$

$$= 0.031 m_h a_h \quad \text{lbf}$$

where

a_{hX} = $0.2g$ in longitudinal direction, in m/s^2 (ft/s^2)

a_{hY} = $0.5g$ in transverse direction, in m/s^2 (ft/s^2)

m_h = sum of mass of cargo lashed on the hatch cover and mass of hatch cover, in kg (lb)

g as defined in 3-5-1/13.3.2.

The accelerations in longitudinal direction and in transverse direction do not need to be considered as acting simultaneously.

11.23.2(b) Hatch Cover Supports. For the transmission of the support forces resulting from the load cases specified in 3-2-12/5.3 through 3-2-12/5.5 and 3-2-12/11.9, and of the horizontal mass forces specified in 3-2-12/11.23.2(a), supports are to be provided which are to be designed such that the nominal surface pressures in general do not exceed the following values:

$p_{n\max} = d_h\, p_n$ N/mm^2 (kgf/mm^2, psi)

where

d_h = 3.75 – 0.015L where L in m

= 3.75 – 0.004572L where L in ft

$d_{h\max}$ = 3.0

$d_{h\min}$ = 1.0 in general

= 2.0 for partial loading conditions, see 3-2-12/11.11.1

p_n = see 3-2-12/Table 8

For metallic supporting surfaces not subjected to relative displacements the nominal surface pressure applies:

$p_{n\max} = 3p_n$ N/mm^2 (kgf/mm^2, psi)

When the maker of vertical hatch cover support material can provide proof that the material is sufficient for the increased surface pressure, not only statically but under dynamic conditions including relative motion for adequate number of cycles, permissible nominal surface pressure may be relaxed at the discretion. However, realistic long term distribution of spectra for vertical loads and relative horizontal motion are subject to approval.

Drawings of the supports must be submitted. In the drawings of supports the permitted maximum pressure given by the material manufacturer must be specified.

TABLE 8
Permissible Nominal Surface Pressure p_n *(1 July 2018)*

Support Material	*p_n N/mm² (kgf/mm², psi) when loaded by:*	
	Vertical Force	*Horizontal Force (on Stoppers)*
Hull structural steel	25 (2.55, 3626)	40 (4.08, 5802)
Hardened steel	35 (3.57, 5076)	50 (5.10, 7252)
Lower friction materials	50 (5.10, 7252)	–

Where large relative displacements of the supporting surfaces are to be expected, the use of material having low wear and frictional properties is recommended.

The substructures of the supports must be of such a design that a uniform pressure distribution is achieved.

Irrespective of the arrangement of stoppers, the supports must be able to transmit the following force P_{sh} in the longitudinal and transverse direction:

$$P_{sh} = \alpha \cdot \frac{P_{sV}}{\sqrt{d_h}}$$

where

P_{sV} = vertical supporting force

α is as defined in 3-5-1/13.3.2.

For non-metallic, low-friction support materials on steel, the friction coefficient may be reduced but not to be less than 0.35.

Supports as well as the adjacent structures and substructures are to be designed such that the permissible stresses according to 3-2-12/11.1.1 are not exceeded.

For substructures and adjacent structures of supports subjected to horizontal forces P_{sh}, fatigue strength is to be considered in the design.

11.23.2(c) Hatch Cover Stoppers. Hatch covers shall be sufficiently secured against horizontal shifting. Stoppers are to be provided for hatch covers on which cargo is carried.

The greater of the loads resulting from 3-2-12/5.5 and 3-2-12/11.23.2(a) is to be applied for the dimensioning of the stoppers and their substructures.

The permissible stress in stoppers and their substructures, in the cover, and of the coamings is to be determined according to 3-2-12/11.1.1. In addition, the provisions in 3-2-12/11.23.2(b) are to be observed.

11.25 Corrosion Addition and Steel Renewal

11.25.1 Corrosion Addition for Hatch Covers and Hatch Coamings

The scantling requirements of the above sections imply the following general corrosion additions t_S:

TABLE 9
Corrosion Additions t_S for Hatch Covers and Hatch Coamings *(1 July 2018)*

Application	*Structure*	*t_S mm (in.)*
Weather deck hatches of container ships, car carriers, paper carriers, passenger vessels	Hatch covers	1.0 (0.04)
	Hatch coamings	1.0 (0.04)
Weather deck hatches of all other ship types covered by this Section	Hatch covers in general	2.0 (0.08)
	Weather exposed plating and bottom plating of double skin hatch covers	1.5 (0.06)
	Internal structure of double skin hatch covers and closed box girders	1.0 (0.04)
	Hatch coamings not part of the longitudinal hull structure	1.5 (0.06)
	Hatch coamings part of the longitudinal hull structure	1.0 (0.04)
	Coaming stays and stiffeners	1.5 (0.06)

11.25.2 Steel Renewal

Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm (t_{net} + 0.02 in.) for

- Single skin hatch covers,
- The plating of double skin hatch covers, and
- Coaming structures the corrosion additions t_S of which are provided in 3-2-12/Table 9.

Where the gauged thickness is within the range t_{net} + 0.5 mm (t_{net} + 0.02 in.) and t_{net} + 1.0 mm (t_{net} + 0.04 in.), coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating is to be maintained in condition with only minor spot rusting.

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

For corrosion addition t_S = 1.0 mm (0.04 in.) the thickness for steel renewal is t_{net} mm (in.) and the thickness for coating or annual gauging is when gauged thickness is between t_{net} mm (in.) and t_{net} + 0.5 mm (t_{net} + 0.02 in.).

(Renumber existing 3-2-12/Table 2 as 3-2-12/Table 10 and existing 3-2-12/Figures 1 and 2 as 3-2-12/Figures 13 and 14.)

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 2 HULL STRUCTURES AND ARRANGEMENTS

SECTION 15 CEILING, SPARRING AND PROTECTION OF STEEL

5 Protection of Steel Work

(Revise Paragraph 3-2-15/5.1, as follows:)

5.1 All Spaces *(1 July 2018)*

Unless otherwise approved, all steel surfaces are to be suitably coated with paint and/or cathodic protection as applicable. For more details, refer to the ABS *Guidance Notes on Cathodic Protection of Ships* and the ABS *Guidance Notes on the Application and Inspection of Marine Coating Systems.*

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 2 HULL STRUCTURES AND ARRANGEMENTS

SECTION 17 MACHINERY SPACE AND TUNNEL *(1 July 2018)*

1 General

1.1 Arrangement

In view of the effect upon the structure of the necessary openings in the machinery space, the difficulty of securing adequate support for the decks, of maintaining the stiffness of sides and bottom and of distributing the weight of the machinery, special attention is directed to the need for arranging, in the early stages of design, for the provision of plated through beams and such casing and pillar supports as are required to secure structural efficiency. Careful attention to these features in design and construction is to be regarded as of the utmost importance.

i) All parts of the machinery, shafting, etc., are to be efficiently supported and the adjacent structure is to be adequately stiffened.

ii) In twin-screw vessels it is necessary to make additions to the strength of the structure and the area of attachments, in proportion to the weight, power and dimensions of the machinery, especially where engines are relatively high in proportion to the width of the bed plate.

iii) The height and approximate weight of engines are to be stated upon the bolting plan, which is to be approved before the bottom construction is commenced. It is determined that the foundations for main propulsion units, reduction gears, shaft and thrust bearings, and the structure supporting those foundations are adequate in strength and rigidity, to maintain required alignment under all anticipated conditions of loading.

iv) Consideration is to be given to the submittal of plans of the foundations for main propulsion units, reduction gears, and thrust bearings and of the structure supporting those foundations to the machinery manufacturer for review. (See 4-3-1/21).

1.3 Testing of Tunnels

Requirements for testing are contained in Part 3, Chapter 7.

3 Machinery Foundations

3.1 Engine Foundations

3.1.1 Single Bottom Vessels

In vessels with single bottoms, the engines and reduction gears are to be seated on thick plates laid across the top of deep floors or upon heavy foundation girders efficiently bracketed and stiffened. Intercostal plates are to be fitted between the floors beneath the lines of bolting to distribute the weight effectively through the bottom structure to the shell. Seat plates are to be of thickness and width appropriate to the holding-down bolts and are to be effectively attached to girders and intercostals.

3.1.2 Double Bottom Vessels

In vessels with double bottoms, the engines are to be seated directly upon thick inner-bottom plating or upon thick seat plates on top of heavy foundations arranged to distribute the weight effectively. Additional intercostal girders are to be fitted within the double bottom, to ensure the satisfactory distribution of the weight and the rigidity of the structure.

3.3 Boiler Foundations

Boilers, if provided, are to be supported by deep saddle-type floors or by transverse or fore-and-aft girders arranged to distribute the weight effectively. Where they are supported by transverse saddles or girders, the floors in way of boilers are to be suitably increased in thickness and specially stiffened (refer to 3-2-4/5.1 of the *Steel Vessel Rules*). Boilers are to be installed such, as to ensure accessibility and proper ventilation being at least 460 mm (18 in.) clear of tank tops, bunker walls, etc. The thickness of adjacent material is to be increased where the clear space is unavoidably sparse. The available clearance is to be indicated on the plans submitted for approval.

3.5 Thrust Foundations

Thrust blocks are to be bolted to efficient foundations extending well beyond the thrust blocks and arranged to distribute the loads effectively into the adjacent structure. Extra intercostal girders, effectively attached, are to be fitted in way of the foundations, as may be required.

3.7 Shaft Bearing and Auxiliary Machinery Foundations

Foundations of the shaft bearings are to be strong, stiff and integrated into surrounding structure. Auxiliary machinery foundations are to be proportioned to the weight supported.

5 Tunnels and Tunnel Recesses

5.1 Plating

The plating of flat sides of shaft or other watertight tunnels is to be of the thickness as obtained from 3-2-7/5.1 for watertight bulkheads; but the lowest strake of the plating is to be increased 1 mm (0.04 in.). Flat plating on the tops of tunnels or tunnel recesses is to be of the thickness required for watertight bulkhead plating at the same level. Neither where the top of the tunnel or recess forms a part of a deck the thickness is to be less than required for the plating of watertight bulkheads at the same level plus 1 mm (0.04 in.) nor less than would be required for the deck plating in the same location. Curved plating may be of the thickness required for watertight bulkhead plating at the same level in association using stiffener spacing of 150 mm (6 in.) less than actually adopted. Crown plating in way of hatches is to be increased at least 2.5 mm (0.10 in.) or is to be protected by wood sheathing of not less than 50 mm (2 in.) thick.

5.3 Stiffeners

Stiffeners are not to be spaced more than 915 mm (36 in.) apart and each stiffener, in association with the plating to which it is attached, is to have a section modulus *SM* not less than obtained from the following equation:

$$SM = 4.42\, hs\ell^2 \quad \text{cm}^3$$

$$SM = 0.0023\, hs\ell^2 \quad \text{in}^3$$

where

h = distance, in m (ft), from the middle of ℓ to the bulkhead deck at center

s = spacing of stiffeners, in m (ft)

ℓ = distance, in m (ft), between the top and bottom supporting members without brackets

The ends of stiffeners are to be welded to the top and bottom supporting members. Where masts, stanchions, etc., are stepped upon tunnels, local strengthening is to be provided proportional to the weight carried.

5.5 Beams, Pillars and Girders

Beams, pillars and girders under the tops of tunnels, or tunnel recesses are to be as required for similar members on bulkhead recesses.

5.7 Tunnels through Deep Tanks

Where tunnels pass through deep tanks, the thickness of the plating and the size of the stiffeners in way of the tanks is not to be less than required for deep-tank bulkheads. Tunnels of circular form are to have plating of not less thickness *t* than obtained from the following equation:

$$t = 0.1345\, dh + 9 \quad \text{mm}$$

$$t = 0.000492\, dh + 0.36 \quad \text{in.}$$

where

d = diameter of the tunnel, in m (ft)

h = distance, in m (ft), from the bottom of the tunnel to the highest point of the following:

the scantling draft line

the highest level to which the tank contents may rise in service conditions

a point located at a distance two-thirds *D*, as defined in 3-1-1/7.1, above the baseline

a point located two-thirds of the test head above the top of the tank

PART 3 HULL CONSTRUCTION AND EQUIPMENT

CHAPTER 5 EQUIPMENT

SECTION 1 ANCHORING, MOORING, AND TOWING EQUIPMENT

(Revise Subsection 3-5-1/1, as follows:)

1 General *(1 July 2018)*

All self-propelled vessels are to have anchors and chains. The anchors and their cables are to be connected and positioned ready for use. Means are to be provided for stopping each cable as it is paid out and the windlass is to be capable of heaving in either cable. Suitable arrangements are to be provided for securing the anchors and stowing the cables. Cables which are intended to form part of the equipment are not to be used as check chains when the vessel is launched. The inboard ends of the cables of the bower anchors are to be secured by efficient means (see 3-5-1/15).

Equipment Number calculations for unconventional vessels with unique topside arrangements or operational profiles may be specially considered. Such consideration may include accounting for additional wind areas of widely separated deckhouses or superstructures in the equipment number calculations or equipment sizing based on direct calculations. However, in no case may direct calculations be used to reduce the equipment size to be less than that required by 3-5-1/3.

The requirements herein are intended for temporary mooring of a vessel within a harbor or sheltered area when the vessel is awaiting berth, tide, etc. IACS Recommendation No. 10 "Anchoring, Mooring and Towing Equipment" may be referred to for recommendations concerning anchoring equipment for vessels in deep and unsheltered water.

The equipment is therefore not designed to hold a vessel off fully exposed coasts in rough weather or to stop a ship that is moving or drifting. In this condition, the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large vessels. The anchoring equipment required herewith is designed to hold a vessel in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground, the holding power of the anchors is significantly reduced.

The strength of supporting hull structures in way of shipboard fittings used for mooring operations and towing operations as well as supporting hull structures of winches and capstans at the bow, sides and stern are to comply with the requirements of 3-2-6/1.6.

3 Calculation of EN

(Revise Paragraph 3-5-1/3.1, as follows:)

3.1 Basic Equation *(1 July 2018)*

The basic Equipment Number (EN) is to be obtained from the following equation for use in determining required equipment.

$$EN = k\Delta^{2/3} + mBh + nA$$

where

k = 1.0 (1.0, 1.012)

m = 2 (2, 0.186)

n = 0.1 (0.1, 0.00929)

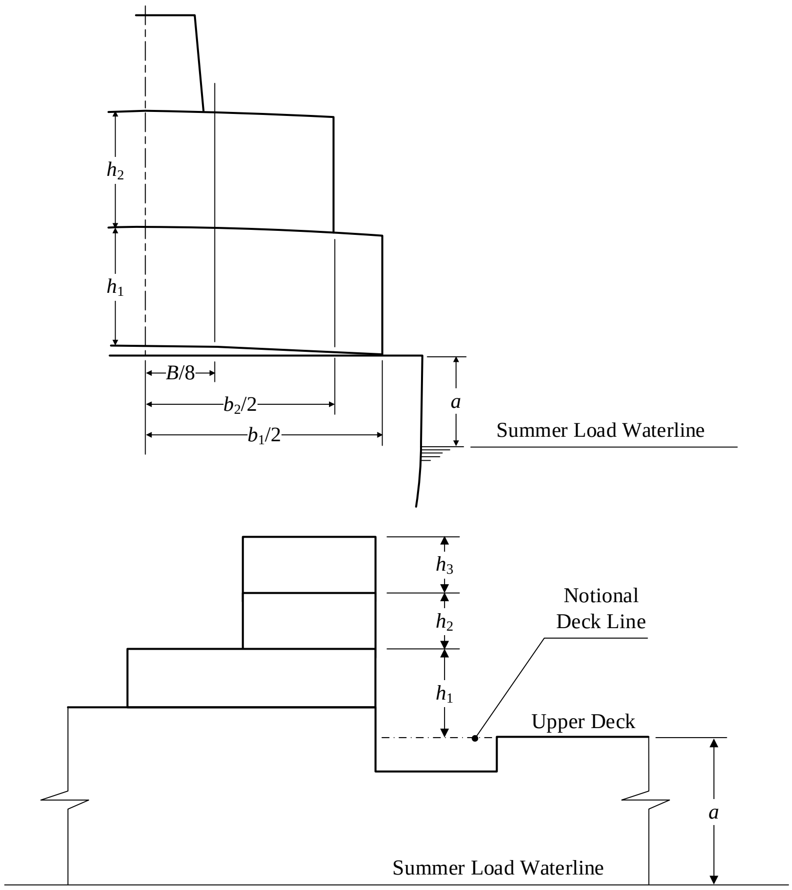
Δ = molded displacement, in metric tons (long tons), to the summer load waterline

B = molded breadth, as defined in 3-1-1/5, in m (ft)

h	=	effective height, in m (ft), from the Summer Load waterline to the top of the uppermost house; for the lowest tier, h is to be measured at centerline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck, as shown in 3-5-1/Figure 1
	=	$a + h_1 + h_2 + h_3 + \ldots$, as shown in 3-5-1/Figure 1. In the calculation of h, sheer and trim may be neglected
a	=	freeboard, in m (ft), from the summer load waterline amidships.
$h_1, h_2, h_3\ldots$	=	height, in m (ft), on the center line of each tier of houses having a breadth greater than B/4

(Revise 3-5-1/Figure 1, as follows:)

FIGURE 1
Effective Heights of Deckhouses *(1 July 2018)*



13 Windlass or Winch Support Structure

13.3 Support Structure *(2004)*

13.3.2 Sea Loads *(2014)*

(Revise Item 3-5-1/13.3.2(d), as follows:)

13.3.2(d) Allowable Stress (1 July 2018)

i) *Bolts.* The safety factor against bolt proof strength is to be not less than 2.0.

ii) *Supporting Structures.* The allowable stresses in the above deck framing and the hull structure supporting the windlass and chain stopper are as follows:

- Normal stress: 100% of the specified minimum yield stress of the material
- Shear stress: 60% of the specified minimum yield stress of the material

iii) The net minimum scantlings of the supporting hull structure are to comply with the requirements given in 3-5-1/13.3.2(d)ii). The required gross scantlings are determined according to 3-2-6/1.6.4.

(Renumber Subsection 3-5-1/15 as 3-5-1/14.)

(Add new Subsections 3-5-1/15 and 3-5-1/16, as follows:)

15 Securing of the Inboard Ends of Chain Cables *(1 July 2018)*

Arrangements are to be provided for securing the inboard ends of the bower anchor chain cables. The chain cables are to be secured to structures by a fastening able to withstand a force not less than 15% nor more than 30% of the breaking load of the chain cable. The fastening is to be provided with a mean suitable to permit, in case of emergency, an easy slipping of the chain cables to sea, operable from an accessible position outside the chain locker.

16 Securing of Stowed Anchors *(1 July 2018)*

Arrangements are to be provided for securing the anchors and stowing the cables. To hold the anchor tight in against the hull or the anchor pocket, respectively, anchor lashings (e.g., a “devil’s claw”) are to be fitted. Anchor lashings are to be designed to resist a load at least corresponding to twice the anchor mass plus 10 m (32.8 ft) of cable without exceeding 40% of the yield strength of the material.

(Revise Subsection 3-5-1/17, as follows:)

17 Mooring and Towing Equipment *(1 July 2018)*

17.1 All Vessels

Hawsers and towlines and requirements for associated equipment and arrangements as described in in 3-5-1/17.9 and 3-5-1/17.11 are not required as a condition of classification. The hawsers and towlines listed in 3-5-1/Table 2 and 3-5-1/Table 3 are intended as a minimum guide.

17.3 Mooring Lines

The mooring lines for vessels with Equipment Number EN of less than or equal to 2000 are given in 3-5-1/17.3.1. For other vessels, the mooring lines are given in 3-5-1/17.3.2.

The Equipment Number EN is to be calculated in compliance with 3-5-1/3. Deck cargo as given by the loading manual is to be included for the determination of side-projected area *A*.

17.3.1 Mooring Lines for Vessels with EN ≤ 2000

The minimum mooring lines for vessels having an Equipment Number EN of less than or equal to 2000 are given in 3-5-1/Table 2 is intended as a guide.

For vessels having an *A/EN* ratio greater than 0.9 for SI or MKS units (9.7 for US units), the number of hawsers given in 3-5-1/Table 2 is to be increased by the number given below:

A/EN Ratio		Increase number of hawsers by
SI Units MKS Units	U.S. Units	
Above 0.9 up to 1.1	above 9.7 up to 11.8	1
Above 1.1 up to 1.2	above 11.8 up to 12.9	2
above 1.2	above 12.9	3

17.3.2 Mooring Lines for Vessels with EN > 2000

The minimum strength and number of mooring lines for vessels with an Equipment Number *EN* > 2000 are given in 3-5-1/17.3.2(a) and 3-5-1/17.3.2(b), respectively, and is intended as a guide. The length of mooring lines is given by 3-5-1/17.3.3.

The strength of mooring lines and the number of head, stern, and breast lines (see Note below defining head, stern, and breast lines) for vessels with an Equipment Number *EN* > 2000 are based on the side-projected area A_1. Side projected area A_1 should be calculated similar to the side-projected area *A* according to 3-5-1/3 but considering the following conditions:

- For oil tankers, chemical tankers, bulk carriers, and ore carriers the lightest ballast draft is to be considered for the calculation of the side-projected area A_1. For other vessels the lightest draft of usual loading conditions is to be considered if the ratio of the freeboard in the lightest draft and the full load condition is equal to or above two. Usual loading conditions are loading conditions as given by the trim and stability booklet that are expected to regularly occur during operation and, in particular, that exclude light weight conditions, propeller inspection conditions, etc.
- Wind shielding of the pier may be considered for the calculation of the side-projected area A_1 unless the vessel is intended to be regularly moored to jetty type piers. A height of the pier surface of 3 m (9.8 ft) over waterline may be assumed (i.e., the lower part of the side-projected area with a height of 3 m (9.8 ft) above the waterline) for the considered loading condition and may be disregarded for the calculation of the side-projected area A_1.
- Deck cargo as given by the loading manual is to be included for the determination of side-projected area A_1. Deck cargo may not need to be considered if a usual light draft condition without cargo on deck generates a larger side-projected area A_1 than the full load condition with cargo on deck. The larger of both side-projected areas is to be chosen as side-projected area A_1.

The mooring lines as given here under are based on a maximum current speed of 1.0 m/s (3.3 ft/s) and the following maximum wind speed v_w, in m/s (ft/s):

v_w = $25.0 - 0.002\,(A_1 - 2000)$ m/s — for passenger vessels, ferries, and car carriers with $2000 \text{ m}^2 < A_1 \le 4000 \text{ m}^2$

= 21.0 m/s — for passenger vessels, ferries, and car carriers with $A_1 > 4000 \text{ m}^2$

= 25.0 m/s — for other vessels

= $82.0 - 0.00061\,(A_1 - 21528)$ ft/s — for passenger vessels, ferries, and car carriers with $21528 \text{ ft}^2 < A_1 \le 43056 \text{ ft}^2$

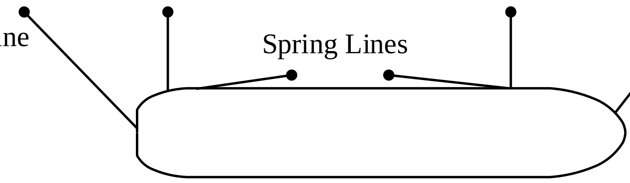
=	68.9 ft/s	for passenger vessels, ferries, and car carriers with A_1 > 43056 ft^2
=	82.0 ft/s	for other vessels

The wind speed is considered representative of a 30 second mean speed from any direction and at a height of 10 m (32.8 ft) above the ground. The current speed is considered representative of the maximum current speed acting on bow or stern (±10°) and at a depth of one-half of the mean draft. Furthermore, it is considered that vessels are moored to solid piers that provide shielding against cross current.

Additional loads caused by, e.g., higher wind or current speeds, cross currents, additional wave loads, or reduced shielding from non-solid piers may need to be particularly considered. Furthermore, it should be observed that unbeneficial mooring layouts can considerably increase the loads on single mooring lines.

Note: The following is defined with respect to the purpose of mooring lines, see also figure below:

- *Breast Line:* A mooring line that is deployed perpendicular to the vessel, restraining the vessel in the off-berth direction.
- *Spring Line:* A mooring line that is deployed almost parallel to the vessel, restraining the vessel in the fore or aft direction.
- *Head/Stern Line:* A mooring line that is oriented between longitudinal and transverse direction, restraining the vessel in the off-berth and in fore or aft direction. The amount of restraint in the fore or aft and off-berth directions depends on the line angle relative to these directions.



17.3.2(a) Minimum Breaking Strength. The minimum breaking strength, in kN (kgf, lbf), of the mooring lines should be taken as:

$$\text{MBL} = 0.1 \cdot A_1 + 350 \quad \text{kN}$$

$$\text{MBL} = 10.20 \cdot A_1 + 35690 \quad \text{kgf}$$

$$\text{MBL} = 2.089 \cdot A_1 + 78680 \quad \text{lbf}$$

The minimum breaking strength may be limited to 1275 kN (130,000 kgf, 286,600 lbf). However, in this case the moorings are to be considered as not sufficient for environmental conditions given by 3-5-1/17.3.2. For these vessels, the acceptable wind speed v_w*, in m/s, can be estimated as follows:

$$\text{MBL}^* \geq \left(\frac{21}{v_w}\right)^2 \cdot \text{MBL} \qquad \text{for } v_w \text{ in m/s}$$

$$\text{MBL}^* \geq \left(\frac{68.9}{v_w}\right)^2 \cdot \text{MBL} \qquad \text{for } v_w \text{ in ft/s}$$

where

v_w	=	wind speed as per 3-5-1/17.3.2
MBL*	=	breaking strength of the mooring lines intended to be supplied
MBL	=	breaking strength according to the above formula

However, the minimum breaking strength should not be taken less than corresponding to an acceptable wind speed of 21 m/s (68.9ft/s):

If lines are intended to be supplied for an acceptable wind speed v_w* higher than v_w as per 3-5-1/17.3.2, the minimum breaking strength should be taken as:

$$MBL^* = \left(\frac{v_w^*}{v_w}\right)^2 \cdot MBL$$

17.3.2(b) Number of Mooring Lines. The total number of head, stern, and breast lines (see Note in 3-5-1/17.3.2) should be taken as:

$n = 8.3 \cdot 10^{-4} \cdot A_1 + 6$ for A_1 in m^2

$n = 7.71 \cdot 10^{-5} \cdot A_1 + 6$ for A_1 in ft^2

For oil tankers, chemical tankers, bulk carriers, and ore carriers the total number of head, stern, and breast lines should be taken as:

$n = 8.3 \cdot 10^{-4} \cdot A_1 + 4$ for A_1 in m^2

$n = 7.71 \cdot 10^{-5} \cdot A_1 + 4$ for A_1 in ft^2

The total number of head, stern, and breast lines should be rounded to the nearest whole number.

The number of head, stern, and breast lines may be increased or decreased in conjunction with an adjustment to the strength of the lines. The adjusted strength, MBL*, should be taken as:

$MBL^* = 1.2 \cdot MBL \cdot n/n^* \leq MBL$ for increased number of lines

$MBL^* = MBL \cdot n/n^*$ for reduced number of lines

where

n^* = increased or decreased total number of head, stern and breast lines

n = number of lines for the considered vessel type as calculated by the above formulas without rounding.

Similarly, the strength of head, stern, and breast lines may be increased or decreased in conjunction with an adjustment to the number of lines.

The total number of spring lines (see Note in 3-5-1/17.3.2) is not to be taken as less than:

Two lines, where $EN < 5000$

Four lines, where $EN \geq 5000$

The strength of spring lines is to be the same as that of the head, stern, and breast lines. If the number of head, stern, and breast lines is increased in conjunction with an adjustment to the strength of the lines, the number of spring lines is to be likewise increased, but rounded up to the nearest even number.

17.3.3 Length of Mooring Lines

The length of mooring lines for vessels with *EN* of less than or equal to 2000 may be taken from 3-5-1/Table 2. For vessels with *EN* > 2000 the length of mooring lines may be taken as 200 m (109 fathoms).

The lengths of individual mooring lines may be reduced by up to 7% of the above given lengths, but the total length of mooring lines should not be less than would have resulted had all lines been of equal length.

17.5 Tow line

The tow lines are given in 3-5-1/Table 3 and are intended as a vessel's own tow line of a vessel being towed by a tug or other vessel. For the selection of the tow line from 3-5-1/Table 3, the Equipment Number (EN) is to be taken according to 3-5-1/3.

17.7 Mooring and Tow Line Construction

Tow lines and mooring lines may be of wire, natural fiber, or synthetic fiber construction or of a mixture of wire and fiber. For synthetic fiber ropes it is recommended to use lines with reduced risk of recoil (snap-back) to mitigate the risk of injuries or fatalities in the case of breaking mooring lines.

Notwithstanding the requirements given in 3-5-1/17.3 and 3-5-1/17.5, no fiber rope is to be less than 20 mm (0.79 in) in diameter. For polyamide ropes, the minimum breaking strength is to be increased by 20% and for other synthetic ropes by 10% to account for strength loss due to, among others, aging and wear.

17.9 Mooring Winches

17.9.1

Each winch is to be fitted with brakes with a holding capacity sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80% of the minimum breaking strength of the rope as fitted on the first layer. The winch is to be fitted with brakes that will allow for the reliable setting of the brake rendering load.

17.9.2

For powered winches the maximum hauling tension which can be applied to the mooring line (the reeled first layer) is not be less than 1/4.5 times, nor be more than $^{1}/_{3}$ times the rope's minimum breaking strength. For automatic winches, these figures apply when the winch is set to the maximum power with automatic control.

17.9.3

For powered winches on automatic control, the rendering tension that the winch can exert on the mooring line (the reeled first layer) is not to exceed 1.5 times, nor be less than 1.05 times the hauling tension for that particular power setting of the winch. The winch is to be marked with the range of rope strength for which it is designed.

17.11 Mooring and Towing Arrangement

17.11.1 Mooring Arrangement

Mooring lines in the same service (e.g., breast lines, see Note in 3-5-1/17.11.2) should be of the same characteristic in terms of strength and elasticity.

As far as possible, a sufficient number of mooring winches are to be fitted to allow for all mooring lines to be belayed on winches. This allows for an efficient distribution of the load to all mooring lines in the same service and for the mooring lines to shed load before they break. If the mooring arrangement is designed such that mooring lines are partly to be belayed on bitts or bollards, these lines are considered to be not as effective as the mooring lines belayed on winches.

Mooring lines are to have a lead as straight as is practicable from the mooring drum to the fairlead.

At points of change in direction, sufficiently large radii of the contact surface of a rope on a fitting are to be provided to minimize the wear experienced by mooring lines and as recommended by the rope manufacturer for the rope type intended to be used.

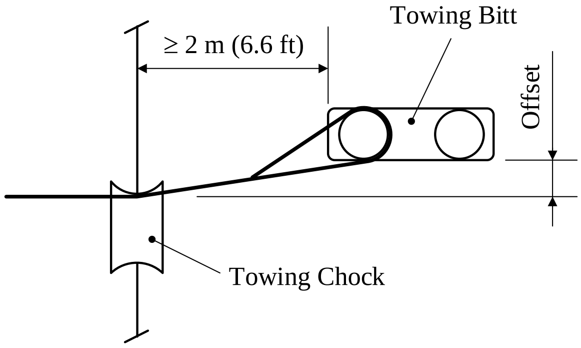
17.11.2 Towing Arrangement

Towing lines, in general, should be led through a closed chock. The use of open fairleads with rollers or closed roller fairleads is to be avoided.

For towing purposes, at least one chock is to be provided close to centerline of the vessel forward and aft. It is also beneficial to provide additional chocks on port and starboard side at the transom and at the bow.

Towing lines are to have a straight lead from the towing bitt or bollard to the chock.

For the purpose of towing, bitts or bollards serving a chock are to be located slightly offset and in a distance of at least 2 m (6.6 ft) away from the chock, see figure below:



As far as practicable, warping drums are to be positioned not more than 20 m (65.6 ft) away from the chock, measured along the path of the line.

Attention is to be given to the arrangement of the equipment for towing and mooring operations in order to prevent interference of mooring and towing lines as far as practicable. It is beneficial to provide dedicated towing arrangements separate from the mooring equipment.

For all vessels, it is recommended to provide towing arrangements fore and aft of sufficient strength for 'other towing' service as defined in 3-2-6/1.6.2(b).

(Revise Subsection 3-5-1/19, as follows:)

19 Bollard, Fairlead and Chocks *(1 July 2018)*

19.1 General *(1 July 2018)*

For vessels which are required to comply with SOLAS, the arrangements and details of shipboard fittings used for mooring operations and/or towing operations at bow, sides and stern are to comply with the requirements of this section. The requirements for the supporting structures of these deck fittings are specified in 3-2-6/1.6.

19.3 Shipboard Fittings

The size of shipboard fittings is to be in accordance with recognized standards (e.g., ISO 13795 Ships and marine technology – Ship's mooring and towing fittings – Welded steel bollards for sea-going vessels) or comply with the requirements given in 3-5-1/19.3.1 and 3-5-1/19.3.2. For shipboard fittings not in accordance with recognized standard the corrosion addition, t_c, and the wear allowance, t_w, given in 3-2-6/1.6.4, respectively, are to be considered. The design load used to assess shipboard fittings and their attachments to the hull are to be in accordance with the requirements as specified in 3-2-6/1.6.

19.3.1 Mooring Operations

Shipboard fittings may be selected from a recognized national or international standard. The Safe Working Load (SWL) is to be suitable for mooring lines with a minimum breaking strength that is not less than that according to 3-5-1/Table 2 [see Notes in 3-2-6/1.6.2(a)].

Mooring bitts (double bollards) are to be chosen for the mooring line attached in figure-of-eight fashion if the industry standard distinguishes between different methods to attach the line (i.e., figure-of-eight or eye splice attachment).

When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the vessel is to be in accordance with requirements related to mooring in 3-2-6/1.6.2 and 3-2-6/1.6.3. Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion, see Note. For strength assessment beam theory or finite element analysis using net scantlings is to be applied, as appropriate. Corrosion additions are to be as defined in 3-2-6/1.6.4(b). A wear down allowance is to be included as defined in 3-2-6/1.6.4(c). Consideration may be given to accepting load tests as alternative to strength assessment by calculations.

Note: With the line attached to a mooring bitt in the usual way (figure-of-eight fashion), either of the two posts of the mooring bitt can be subjected to a force twice as large as that acting on the mooring line. Disregarding this effect, depending on the applied industry standard and fitting size, overload may occur.

19.3.2 Towing Operations

Shipboard fittings may be selected from a recognized industry standard and are to be at least based on the following loads:

i) For normal towing operations, the intended maximum towing load (e.g., static bollard pull) as indicated on the towing and mooring arrangements plan,

ii) For other towing service, the minimum breaking strength of the tow line according to 3-5-1/Table 3 (see Notes in 3-2-6/1.6.2(b) for other towing services),

iii) For fittings intended to be used for, both, normal and other towing operations, the greater of the loads according to *i)* and *ii)*.

Towing bitts (double bollards) may be chosen for the towing line attached with eye splice if the industry standard distinguishes between different methods to attach the line (i.e., figure-of-eight or eye splice attachment).

When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the vessel is to be in accordance with requirements related to towing in 3-2-6/1.6.2 and 3-2-6/1.6.3. Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice. For strength assessment beam theory or finite element analysis using net scantlings is to be applied, as appropriate. Corrosion additions are to be as defined in 3-2-6/1.6.4(b). A wear down allowance is to be included as defined in 3-2-6/1.6.4(c). Consideration may be given to accepting load tests as alternative to strength assessment by calculations.

19.5 Safe Working Load (SWL) and Towing Load (TOW)

The requirements on SWL apply for a single post basis (no more than one turn of one cable).

19.5.1 Mooring Operations

i) The Safe Working Load (SWL) is the load limit for mooring purpose.

ii) Unless a greater SWL is requested by the applicant according to 3-2-6/1.6.2(c), the SWL is not to exceed the minimum breaking strength of the mooring line according to 3-5-1/Table 2, see Notes in 3-2-6/1.6.2(a).

iii) The SWL, in tonnes, of each shipboard fitting is to be marked (by weld bead or equivalent) on the fittings used for mooring. For fittings intended to be used for both mooring and towing, TOW, in tonnes, according to 3-5-1/19.5.2 is to be marked in addition to SWL.

iv) The above requirements on SWL apply for the use with no more than one mooring line.

v) The towing and mooring arrangements plan mentioned in 3-5-1/19.7 is to define the method of use of mooring lines.

19.5.2 Towing Operations

i) The Safe Towing Load (TOW) is the load limit for towing purpose.

ii) TOW used for normal towing operations is not to exceed 80% of the design load per 3-2-6/1.6.2(b) for normal towing operations.

iii) TOW used for other towing operations is not to exceed 80% of the design load according to 3-2-6/1.6.2(b) for other towing service.

iv) For fittings used for both normal and other towing operations, the greater of the safe towing loads according to *ii)* and *iii)* is to be used.

v) For fittings intended to be used for both towing and mooring, the requirements in 3-2-6/1.6 and 3-5-1/19 applicable to mooring are to be applied relative to mooring operations.

vi) TOW, in tonnes, of each shipboard fitting is to be marked (by weld bead or equivalent) on the fittings used for towing. For fittings intended to be used for both towing and mooring, SWL, in tonnes, according to 3-5-1/19.5.1 is to be marked in addition to TOW.

vii) The above requirements on TOW apply for the use with no more than one line. If not otherwise chosen, for towing bitts (double bollards) TOW is the load limit for a towing line attached with eye-splice.

viii) The towing and mooring arrangements plan mentioned in 3-5-1/19.7 is to define the method of use of towing lines.

19.5.3 Marking and Plan

19.5.3(a) Marking. The SWL of each shipboard fitting is to be marked (by weld bead or equivalent) on the fittings used for towing/mooring.

19.5.3(b) Plan. The towing and mooring arrangements plan mentioned in 3-5-1/19.7 is to define the method of use of mooring lines and/or towing lines.

19.7 Towing and Mooring Arrangements Plan

The SWL and TOW for the intended use for each shipboard fitting is to be noted in the towing and mooring arrangements plan available on board for the guidance of the Master.

Information provided on the plan is to include in respect of each shipboard fitting:

- Location on the vessel;
- Fitting type;
- SWL and TOW;
- Purpose (mooring/harbor towing/other towing); and
- Manner of applying towing or mooring line load including limiting fleet angles.

The above information is to be incorporated into the pilot card in order to provide the pilot proper information on harbor/other towing operations.

In addition, the towing and mooring arrangement plan is to include the following general information:

- The arrangement of mooring lines showing number of lines (N);
- The minimum breaking strength of each mooring line (MBL);
- The acceptable environmental conditions as given in 3-5-1/17.3.2 for the recommended minimum breaking strength of mooring lines for vessels with Equipment Number EN > 2000:
    - 30 second mean wind speed from any direction (v_W or v_W* according to 3-5-1/17.3.2)
    - Maximum current speed acting on bow or stern (±10°)

(Revise 3-5-1/Table 1, as follows:)

TABLE 1
Equipment for Self-propelled Ocean-going Vessels *(1 July 2018)*

SI, MKS Units

The weight per anchor of bower anchors given in 3-5-1/Table 1 is for anchors of equal weight. The weight of individual anchors may vary 7% plus or minus from the tabular weight, provided that the combined weight of all anchors is not less than that required for anchors of equal weight. The total length of chain required to be carried onboard, as given in 3-5-1/Table 1, is to be reasonably divided between the two bower anchors.

		Stockless Bower Anchors		*Chain Cable Stud Link Bower Chain***			
					Diameter		
Equipment Numeral	*Equipment Number**	*Number*	*Mass per Anchor, kg*	*Length, m*	*Normal-Strength Steel (Grade 1), mm*	*High-Strength Steel (Grade 2), mm*	*Extra High-Strength Steel (Grade 3), mm*
UA1	30	2	75	192.5	12.5	—	—
UA2	40	2	100	192.5	12.5	—	—
UA3	50	2	120	192.5	12.5	—	—
UA4	60	2	140	192.5	12.5	—	—
UA5	70	2	160	220	14	12.5	—
UA6	80	2	180	220	14	12.5	—
UA7	90	2	210	220	16	14	—
UA8	100	2	240	220	16	14	—
UA9	110	2	270	247.5	17.5	16	—
UA10	120	2	300	247.5	17.5	16	—
UA11	130	2	340	275	19	16	—
UA12	140	2	390	275	20.5	17.5	—
U6	150	2	480	275	22	19	—
U7	175	2	570	302.5	24	20.5	—
U8	205	2	660	302.5	26	22	20.5
U9	240	2	780	330	28	24	22
U10	280	2	900	357.5	30	26	24
U11	320	2	1020	357.5	32	28	24
U12	360	2	1140	385	34	30	26
U13	400	2	1290	385	36	32	28
U14	450	2	1440	412.5	38	34	30
U15	500	2	1590	412.5	40	34	30
U16	550	2	1740	440	42	36	32
U17	600	2	1920	440	44	38	34
U18	660	2	2100	440	46	40	36
U19	720	2	2280	467.5	48	42	36
U20	780	2	2460	467.5	50	44	38
U21	840	2	2640	467.5	52	46	40
U22	910	2	2850	495	54	48	42
U23	980	2	3060	495	56	50	44
U24	1060	2	3300	495	58	50	46
U25	1140	2	3540	522.5	60	52	46
U26	1220	2	3780	522.5	62	54	48
U27	1300	2	4050	522.5	64	56	50
U28	1390	2	4320	550	66	58	50
U29	1480	2	4590	550	68	60	52
U30	1570	2	4890	550	70	62	54

TABLE 1 (continued)

SI, MKS Units							
		Stockless Bower Anchors		*Chain Cable Stud Link Bower Chain***			
					Diameter		
Equipment Numeral	*Equipment Number**	*Number*	*Mass per Anchor, kg*	*Length, m*	*Normal-Strength Steel (Grade 1), mm*	*High-Strength Steel (Grade 2), mm*	*Extra High-Strength Steel (Grade 3), mm*
U31	1670	2	5250	577.5	73	64	56
U32	1790	2	5610	577.5	76	66	58
U33	1930	2	6000	577.5	78	68	60
U34	2080	2	6450	605	81	70	62
U35	2230	2	6900	605	84	73	64
U36	2380	2	7350	605	87	76	66
U37	2530	2	7800	632.5	90	78	68
U38	2700	2	8300	632.5	92	81	70
U39	2870	2	8700	632.5	95	84	73
U40	3040	2	9300	660	97	84	76
U41	3210	2	9900	660	100	87	78
U42	3400	2	10500	600	102	90	78
U43	3600	2	11100	687.5	105	92	81
U44	3800	2	11700	687.5	107	95	84
U45	4000	2	12300	687.5	111	97	87
U46	4200	2	12900	715	114	100	87
U47	4400	2	13500	715	117	102	90
U48	4600	2	14100	715	120	105	92
U49	4800	2	14700	742.5	122	107	95
U50	5000	2	15400	742.5	124	111	97
U51	5200	2	16100	742.5	127	111	97
U52	5500	2	16900	742.5	130	114	100
U53	5800	2	17800	742.5	132	117	102
U54	6100	2	18800	742.5	—	120	107
U55	6500	2	20000	770	—	124	111
U56	6900	2	21500	770	—	127	114
U57	7400	2	23000	770	—	132	117
U58	7900	2	24500	770	—	137	122
U59	8400	2	26000	770	—	142	127
U60	8900	2	27500	770	—	147	132
U61	9400	2	29000	770	—	152	132
U62	10000	2	31000	770	—	—	137
U63	10700	2	33000	770	—	—	142
U64	11500	2	35500	770	—	—	147
U65	12400	2	38500	770	—	—	152
U66	13400	2	42000	770	—	—	157
U67	14600	2	46000	770	—	—	162

* For intermediate values of equipment number, use equipment complement in sizes and weights given for the lower equipment number in the table.

** Wire ropes may be used in lieu of chain cables for both anchors on vessels less than 30 m (98.4 ft) in length. For vessels between 30 m (8.4 ft) and 40 m (131.2 ft) in length, wire rope may be used in lieu of chain cable for one anchor, provided normal chain cable is provided for the second anchor.

The wire is to have a breaking strength not less than the grade 1 chain of required size and a length of at least 1.5 times the chain it is replacing.

Between the wire rope and anchor, chain cable of the required size having a length of 12.5 m (41.0 ft), or the distance between anchor in stored position and winch, whichever is less, is to be fitted.

All surfaces being in contact with the wire need to be rounded with a radius of not less than 10 times the wire rope diameter (including stem).

TABLE 1
Equipment for Self-propelled Ocean-going Vessels *(1 July 2018)*

US Units

The weight per anchor of bower anchors given in 3-5-1/Table 1 is for anchors of equal weight. The weight of individual anchors may vary 7% plus or minus from the tabular weight, provided that the combined weight of all anchors is not less than that required for anchors of equal weight. The total length of chain required to be carried onboard, as given in 3-5-1/Table 1, is to be reasonably divided between the two bower anchors.

		Stockless Bower Anchors		*Chain Cable Stud Link Bower Chain***			
					Diameter		
Equipment Numeral	*Equipment Number**	*Number*	*Mass per Anchor, pounds*	*Length, fathoms*	*Normal-Strength Steel (Grade 1), inches*	*High-Strength Steel (Grade 2), inches*	*Extra High-Strength Steel (Grade 3), inches*
UA1	30	2	165	105	1/2	—	—
UA2	40	2	220	105	1/2	—	—
UA3	50	2	265	105	1/2	—	—
UA4	60	2	310	105	1/2	—	—
UA5	70	2	350	120	9/16	1/2	—
UA6	80	2	400	120	9/16	1/2	—
UA7	90	2	460	120	5/8	9/16	—
UA8	100	2	530	120	5/8	9/16	—
UA9	110	2	595	135	11/16	5/8	—
UA10	120	2	670	135	11/16	5/8	—
UA11	130	2	750	150	3/4	11/16	—
UA12	140	2	860	150	13/16	11/16	—
U6	150	2	1060	150	7/8	3/4	—
U7	175	2	1255	165	15/16	13/16	—
U8	205	2	1455	165	1	7/8	13/16
U9	240	2	1720	180	1 1/8	15/16	7/8
U10	280	2	1985	195	1 3/16	1	15/16
U11	320	2	2250	195	1 1/4	1 1/8	15/16
U12	360	2	2510	210	1 5/16	1 3/16	1
U13	400	2	2840	210	1 7/16	1 1/4	1 1/8
U14	450	2	3170	225	1 1/2	1 5/16	1 3/16
U15	500	2	3500	225	1 9/16	1 5/16	1 3/16
U16	550	2	3830	240	1 5/8	1 7/16	1 1/4
U17	600	2	4230	240	1 3/4	1 1/2	1 5/16
U18	660	2	4630	240	1 13/16	1 9/16	1 7/16
U19	720	2	5020	255	1 7/8	1 5/8	1 7/16
U20	780	2	5420	255	2	1 3/4	1 1/2
U21	840	2	5820	255	2 1/16	1 13/16	1 9/16
U22	910	2	6280	270	2 1/8	1 7/8	1 5/8
U23	980	2	6740	270	2 3/16	1 15/16	1 3/4
U24	1060	2	7270	270	2 5/16	2	1 13/16
U25	1140	2	7800	285	2 3/8	2 1/16	1 13/16
U26	1220	2	8330	285	2 7/16	2 1/8	1 7/8
U27	1300	2	8930	285	2 1/2	2 3/16	2
U28	1390	2	9520	300	2 5/8	2 5/16	2
U29	1480	2	10120	300	2 11/16	2 3/8	2 1/16
U30	1570	2	10800	300	2 3/4	2 7/16	2 1/8

TABLE 1 (continued)

US Units

Equipment Numeral	*Equipment Number**	*Stockless Bower Anchors: Number*	*Stockless Bower Anchors: Mass per Anchor, pounds*	*Chain Cable Stud Link Bower Chain**: Length, fathoms*	*Diameter: Normal-Strength Steel (Grade 1), inches*	*Diameter: High-Strength Steel (Grade 2), inches*	*Diameter: Extra High-Strength Steel (Grade 3), inches*
U31	1670	2	11600	315	2 7/8	2 1/2	2 3/16
U32	1790	2	12400	315	3	2 5/8	2 5/16
U33	1930	2	13200	315	3 1/16	2 11/16	2 3/8
U34	2080	2	14200	330	3 3/16	2 3/4	2 7/16
U35	2230	2	15200	330	3 5/16	2 7/8	2 1/2
U36	2380	2	16200	330	3 7/16	3	2 5/8
U37	2530	2	17200	345	3 9/16	3 1/16	2 11/16
U38	2700	2	18300	345	3 5/8	3 3/16	2 3/4
U39	2870	2	19200	345	3 3/4	3 5/16	2 7/8
U40	3040	2	20500	360	3 7/8	3 5/16	3
U41	3210	2	21800	360	3 15/16	3 7/16	3 1/16
U42	3400	2	23100	360	4	3 9/16	3 1/16
U43	3600	2	24500	375	4 1/8	3 5/8	3 3/16
U44	3800	2	25800	375	4 1/4	3 3/4	3 5/16
U45	4000	2	27100	375	4 3/8	3 7/8	3 7/16
U46	4200	2	28400	390	4 1/2	3 15/16	3 7/16
U47	4400	2	29800	390	4 5/8	4	3 9/16
U48	4600	2	31100	390	4 3/4	4 1/8	3 5/8
U49	4800	2	32400	405	4 3/4	4 1/4	3 3/4
U50	5000	2	33900	405	4 7/8	4 3/8	3 7/8
U51	5200	2	35500	405	5	4 3/8	3 7/8
U52	5500	2	37200	405	5 1/8	4 1/2	3 15/16
U53	5800	2	39200	405	5 1/8	4 5/8	4
U54	6100	2	41400	405	—	4 3/4	4 1/4
U55	6500	2	44000	420	—	4 7/8	4 3/8
U56	6900	2	47400	420	—	5	4 1/2
U57	7400	2	50700	420	—	5 1/8	4 5/8
U58	7900	2	54000	420	—	5 3/8	4 3/4
U59	8400	2	57300	420	—	5 5/8	5
U60	8900	2	60600	420	—	5 3/4	5 1/8
U61	9400	2	63900	420	—	6	5 1/8
U62	10000	2	68000	420	—	—	5 3/8
U63	10700	2	72500	420	—	—	5 5/8
U64	11500	2	78000	420	—	—	5 3/4
U65	12400	2	85000	420	—	—	6
U66	13400	2	92500	420	—	—	6 1/8
U67	14600	2	101500	420	—	—	6 3/8

* For intermediate values of equipment number, use equipment complement in sizes and weights given for the lower equipment number in the table.

** Wire ropes may be used in lieu of chain cables for both anchors on vessels less than 30 m (98.4 ft) in length. For vessels between 30 m (8.4 ft) and 40 m (131.2 ft) in length, wire rope may be used in lieu of chain cable for one anchor, provided normal chain cable is provided for the second anchor.

The wire is to have a breaking strength not less than the grade 1 chain of required size and a length of at least 1.5 times the chain it is replacing.

Between the wire rope and anchor, chain cable of the required size having a length of 12.5 m (41.0 ft), or the distance between anchor in stored position and winch, whichever is less, is to be fitted.

All surfaces being in contact with the wire need to be rounded with a radius of not less than 10 times the wire rope diameter (including stem).

(Delete existing 3-5-1/Table 2 and add new 3-5-1/Tables 2 and 3, as follows:)

TABLE 2
Mooring Lines for Self-propelled Ocean-going Vessels with *EN* ≤ 2000 *(1 July 2018)*

Equipment Number		*Mooring Lines*					
Exceeding	*Not Exceeding*	*Number*	*Minimum Length of Each Line* *		*Minimum Breaking Strength*		
			(m)	*(fathoms)*	*(kN)*	*(kgf)*	*(lbf)*
50	70	3	80	44	37	3750	8300
70	90	3	100	55	40	4000	9000
90	110	3	110	60	42	4500	9400
110	130	3	110	60	48	5000	10800
130	150	3	120	66	53	5400	11900
150	175	3	120	66	59	6000	13300
175	205	3	120	66	64	6500	14400
205	240	4	120	66	69	7000	15500
240	280	4	120	66	75	7500	16900
280	320	4	140	77	80	8000	18000
320	360	4	140	77	85	8500	19100
360	400	4	140	77	96	9500	21600
400	450	4	140	77	107	11000	24100
450	500	4	140	77	117	12000	26300
500	550	4	160	87	134	13500	30100
550	600	4	160	87	143	14500	32100
600	660	4	160	87	160	16500	36000
660	720	4	160	87	171	17500	38400
720	780	4	170	93	187	19000	42000
780	840	4	170	93	202	20500	45400
840	910	4	170	93	218	22000	49000
910	980	4	170	93	235	24000	52800
980	1060	4	180	98	250	25500	56200
1060	1140	4	180	98	272	27500	61100
1140	1220	4	180	98	293	30000	65900
1220	1300	4	180	98	309	31500	69500
1300	1390	4	180	98	336	34500	75500
1390	1480	4	180	98	352	36000	79100
1480	1570	5	190	104	352	36000	79100
1570	1670	5	190	104	362	37000	81400
1670	1790	5	190	104	384	39000	86300
1790	1930	5	190	104	411	42000	92400
1930	2000	5	190	104	437	44500	98200

* 3-5-1/17.3.3 is to be observed.

TABLE 3
Tow Lines for Self-propelled Ocean-going Vessels *(1 July 2018)*

Equipment Number		*Tow Line*				
Exceeding	*Not Exceeding*	*Minimum Length*		*Minimum Breaking Strength*		
		(m)	*(ft)*	*(kN)*	*(kgf)*	*(lbf)*
50	70	180	98	98	10000	22000
70	90	180	98	98	10000	22000
90	110	180	98	98	10000	22000
110	130	180	98	98	10000	22000
130	150	180	98	98	10000	22000
150	175	180	98	98	10000	22000
175	205	180	98	112	11400	25100
205	240	180	98	129	13200	29100
240	280	180	98	150	15300	33700
280	320	180	98	174	17700	39000
320	360	180	98	207	21100	46500
360	400	180	98	224	22800	50300
400	450	180	98	250	25500	56200
450	500	180	98	277	28200	62200
500	550	190	104	306	31200	68800
550	600	190	104	338	34500	76000
600	660	190	104	370	37800	83300
660	720	190	104	406	41400	91200
720	780	190	104	441	45000	99200
780	840	190	104	479	48900	107800
840	910	190	104	518	52800	116400
910	980	190	104	559	57000	125600
980	1060	200	109	603	61500	135500
1060	1140	200	109	647	66000	145500
1140	1220	200	109	691	70500	155400
1220	1300	200	109	738	75300	166000
1300	1390	200	109	786	80100	176500
1390	1480	200	109	836	85200	187800
1480	1570	220	120	888	90600	199700
1570	1670	220	120	941	96000	211500
1670	1790	220	120	1024	104400	230000
1790	1930	220	120	1109	113100	249500
1930	2080	220	120	1168	119100	262500
2080	2230	240	131	1259	128400	283000
2230	2380	240	131	1356	138300	305000
2380	2530	240	131	1453	148200	326500
2530	2700	260	142	1471	150000	330500
2700	2870	260	142	1471	150000	330500
2870	3040	260	142	1471	150000	330500
3040	3210	280	153	1471	150000	330500
3210	3400	280	153	1471	150000	330500
3400	3600	280	153	1471	150000	330500
3600	---	300	164	1471	150000	330500

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 1 GENERAL

SECTION 1 CLASSIFICATION OF MACHINERY

15 Astern Propulsion Power *(2005)*

(Revise Paragraph 4-1-1/15.1, as follows:)

15.1 General *(1 July 2018)*

Sufficient power for going astern is to be provided to secure proper control of the vessel in all normal circumstances. The astern power of the main propelling machinery is to be capable of maintaining in free route astern at least 70% of the ahead rpm corresponding to the maximum continuous ahead power. For main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive, running astern is not to lead to overload of the propulsion machinery.

Main propulsion systems are to undergo tests to demonstrate the astern response characteristics. The tests are to be carried out at least over the maneuvering range of the propulsion system and from all control positions. A test plan is to be provided by the yard and accepted by the surveyor. If specific operational characteristics have been defined by the manufacturer these shall be included in the test plan. The ability of the machinery, including the blade pitch control system of controllable pitch propellers, to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded during trials.

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 2 PRIME MOVERS

SECTION 1 INTERNAL COMBUSTION ENGINES AND REDUCTION GEARS

1 General

(Revise Paragraph 4-2-1/1.1, as follows:)

1.1 Construction and Installation *(1 July 2018)*

Internal combustion engines of 100 kW [135 horsepower (hp)] and over and associated reduction gears are to be constructed in accordance with Part 4, Chapters 2 and 3 of the *Steel Vessel Rules* and installed in accordance with the following requirements to the satisfaction of the Surveyor. Engines of less than 100 kW (135 hp) and associated reduction gears are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

For engines driving generators, refer to the applicable requirements of 4-6-4/3.17 and 4-6-4/3.19.

Additional requirements for exhaust emission abatement equipment connected to internal combustion engines or boilers are provided in the ABS *Guide for Exhaust Emission Abatement*.

15 Engine Exhaust Systems

(Add new Paragraph 4-2-1/15.7, as follows:)

15.7 Exhaust Emission Abatement Systems *(1 July 2018)*

Where a vessel is fitted with an exhaust emission abatement system and the optional vessel notations detailed under 1/9.3 through 1/9.9 of the ABS *Guide for Exhaust Emission Abatement* are not requested, the installed exhaust emission abatement system is to comply with the minimum requirements prescribed in Section 1, Table 1 of the Guide and is to be verified by an ABS Surveyor during installation. This is applicable to new construction and existing vessel conversions.

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 3 PROPULSION AND MANEUVERING MACHINERY

SECTION 1 PROPULSION SHAFTING

(Add new Subsection 4-3-1/27 and 4-3-1/Table 5, as follows:)

27 Tailshaft Condition Monitoring (TCM-W) *(1 July 2018)*

27.1 Notation

Where requested by the Owner, the class notation **TCM-W (Tailshaft Condition Monitoring - Water Lubricated)** may be assigned to a vessel with tailshafts specifically arranged with closed or opened type water-lubricated stern tube bearings, provided the following requirements are complied with.

Exposed open water-lubricated bearings installed in an I or V shaped shaft struts without forced lubricating systems are not within the scope of this notation.

27.3 System Requirements

27.3.1 General

27.3.1(a) Bearing Material. The bearing material is to be approved by ABS.

27.3.1(b) Corrosion Protection. Approved corrosion-resistant material or a corrosion protection coating are to be used for propeller shaft, stern tube and all seal components (exposed to seawater) of the shaft including other metal structures exposed to the lubricant.

27.3.1(c) Pumping and Piping. The requirements listed in 4-3-1/27.3 for pumping and piping systems associated with the water lubricated system are in addition to those listed in Part 4, Chapter 4 of these Rules.

i) Pumps

- A minimum of two pumps, with an auto change over system, is to be provided for each propeller shaft.
- In case of multi-propeller shafts, at least one pump for each shaft is to be provided and one additional stand-by pump for the combined arrangement.
- Each pump is to be able to operate the system independently.
- Pumps should be able to operate from both local and main control stations.

ii) Lubricant Piping

- Independent lubricating piping systems are to be provided for each propeller shaft so as to maintain continuous operation of the vessel.

- Interconnection of lubricating piping systems will be acceptable where multi-propeller shafts are used, provided appropriate isolation valves are fitted at both sides of the piping system.
- Non-metallic piping is allowed in this essential system provided it meets the requirements of category A and other machinery space (See 4-4-2/Table 2)
- In addition to above, an emergency supply of lubricating water is to be provided in case of failure of the primary lubricating system

iii) *Lubricant Tank (if applicable)*

- Tanks are to be of metallic construction. Alternatively, the designer or builder may use non-metallic construction in accordance with a recognized or international standard acceptable to ABS. Specifications for the tank, including thermal and mechanical properties and chemical and fire resistance, are to be submitted for review.
- Mounting, securing arrangements and electrical bonding arrangements are to be submitted for approval.
- Valves are to be readily accessible and controllable from the floors or gratings. Open or closed indicators are to be provided, see 4-4-2/11.3. Where the valves are power-operated, the valves are to allow for manual operation in the event of a failure of the power supply.
- Tank Vents and Sounding are to comply with 4-4-3/9 and 4-4-3/13.

iv) *Water Filtration System*

- The normal operational condition is to be displayed and any failures are to be alarmed as indicated in 4-3-1/Table 3 below.
- Two independent water filtration systems are to be provided to maintain continuous operation of the vessel.
- An auto change-over system is to be provided in case of failure.

27.3.1(d) Control and Instrument. Instruments for monitoring the water lubricating stern tube system are to be provided, as indicated in 4-3-1/Table 3 below. All alarms are to be audible and visual and are to be of the self-monitoring type so that a circuit failure will cause an alarm condition. There are to be provisions for testing alarms.

TABLE 3
Instrumentation and Alarm *(1 July 2018)*

Monitored Parameter	*System – Opened Loop (OL) & Closed Loop (CL)*	*Alarm Condition*	*Display*	*Local*	*Main Control Station* (2)	*Navigation Bridge* (1, 4)
Flow	OL & CL	Low/High	x	x	x	x
Pressure	OL & CL	Low/High	x	x	x	x
Diff. Pressure (Filter)	OL & CL	High	x	x	x	x
Diff. Pressure (Across S/T)	CL	High	x	x	x	x
Bearing Temperature	OL & CL	High	x	x	x	x
Water Temperature	CL	High	x	x	x	x
Salinity	CL	High	x	x	x	x
Wear Down(3)	OL & CL	High	x	x	x	x
Tank Level	CL	Low	x	x	x	x
Water filtration System	OL & CL	Failure	x	x	x	x
Pump	OL & CL	Failure	x	x	x	x
Power Circuit	OL & CL	Failure	x	x	x	x

Notes:

1 Either an individual indication or a common trouble alarm may be fitted at this location, provided the individual indication is installed at the equipment (or main control station).

2 For vessels not fitted with a main control station, the indication is to be installed at the equipment or other suitable location.

3 Where continuous monitoring system is installed.

4 Applicable only for **ACCU** Notation.

27.3.1(e) Lubricant Sampling and Testing. Sampling and testing procedures are to be available on board as follows:

- A sampling point is to be provided after the water filtration system for periodical testing.
- Suitable test kits are to be provided onboard.
- Testing is to be conducted as per manufacturer's recommendations.
- For closed loop systems, an additional sampling system is to be provided in the return lubricant line, after bearing lubrication.

27.3.1(f) Shaft Alignment Calculations.

- The calculations, alignment procedures, and stern tube inclination details for these shafting arrangements are to comply with 4-3-1/21.3.1.
- Additionally, the shaft alignment calculations are to be analyzed for both initial conditions and conditions of manufacturer's maximum allowable wear down limits.
- All calculations and data are to be submitted to and reviewed by ABS.

27.3.1(g) Wear Down.

- A manual gauge (i.e., poker gauge) is to be provided for measuring the bearing wear down.
- The bearing wear down monitoring system may be provided in addition to the manual system to monitor wear down from ship control system.
- The maximum permitted wear down is to be indicated by the manufacturer. (See 7-5-2/1.1 and 7-5-2/1.3 of the ABS *Rules for Survey After Construction (Part 7)*)
- The measurement history is to be recorded and documented on board.

27.3.2 Closed Loop System

27.3.2(a) Anti-freeze Properties. Appropriate anti-freeze properties of lubricant are to be maintained as per manufacturer's recommendation.

27.3.2(b) Contamination. Means are to be provided to detect sea water contamination into the system.

27.3.2(c) Lubricant Quality. Suitable test kits for lubricant quality are to be made available on board.

27.3.2(d) Overpressure Protection. Provisions are to be made for the suitable pressure relief arrangements.

27.3.2(e) Lubricant pH, Cl. The bearing manufacturer is to provide the acceptable limits for pH and Chloride content.

27.3.2(f) Anti-freeze Properties, Temperature Limit. Bearing manufacturer is to provide the anti-freeze properties, temperature limit (lowest & highest) of lubricant water.

27.3.2(g) Shaft Turning System. Propeller shafts are to be equipped with a turning system, providing for rotation.

27.3.3 Opened Loop System

27.3.3(a) Lubricant Source. Primarily, sea water is to be taken from the sea water main/ sea chest. Other sources may be used in case of emergency and where appropriate quality of lubricant is not available when vessel is operating in unclean water.

27.3.3(b) Shaft Turning System. Propeller shafts are to be equipped with a turning system, providing for rotation.

27.5 Management of the Monitored Data

The following management of the monitored data is to be implemented.

27.5.1 Lubricant Sampling (Closed Loop System)

A sample test of lubricant should be carried out at the following intervals:

i) Samples are to be analyzed monthly by ship's crew.

ii) The documentation on lubricating fresh water analysis is to be available on board, and samples are to be submitted for analysis to a recognized laboratory at least every six (6) months. Analysis to be performed, including the following as a minimum:

- Material contents as applicable (with the material of the shaft, stern tube and liners used).
- Corrosion inhibitors in fresh water (pH or equivalent alkalinity indicators) indicating the degree of passivation of the system against corrosion.
- Salinity indicators or equivalent indicators (i.e., total conductivity).
- Contents of bearing particles.

27.5.2 Wear Down Measurement

Wear down is to be continuously monitored or measured using manual device at least twice in five years (not to exceed 36 month intervals) and recorded. Records are to be made available to the attending Surveyor.

27.5.3 Bearings Operating Condition

Stern tube bearing temperatures are to be continuously monitored and recorded. Where bearing material properties or bearing arrangements do not require temperature monitoring, consideration may be given by ABS on a case-by-case basis.

27.5.4 Lubricant Operating Condition

Lubricant flow is to be continuously monitored and recorded.

27.5.5 Recording and Analysis

The chief engineer is responsible for recording and maintaining a file of the shipboard-performed lubricant sampling and analysis results, as well as stern tube bearings operating condition. The results of the laboratory analysis are to be stored within the file onboard. All documentation is to be made available to the Surveyor to allow for trend assessment of the measured parameters.

27.7 Test Plan

A Test Plan is to be submitted to ABS to serve as the plan review at the start of the plan review process. The test plan is to identify all equipment and systems and the recommended method of performing the tests or trials.

27.9 Surveys

27.9.1 Bearing and Coating Inspection

- Stern tube bearings are to be examined at installation to the satisfaction of the attending Surveyor.
- The shaft sleeve/liner is to be examined at installation to the satisfaction of the attending Surveyor.
- Where direct access is not available, arrangements are to be made for borescope inspection of the system (e.g., bearing, shaft surface, et al.)
- The inspection procedures for corrosion protection coatings and borescope inspection are to be submitted to ABS.

27.9.2 Initial Survey

All systems in 4-3-1/27 are to be examined and tested to the satisfaction of the attending Surveyor in accordance with the approved plans.

For initial survey of existing vessels, refer to 7-9-20/3.3 of the ABS *Rules for Survey After Construction (Part 7).*

27.9.3 Survey After Construction

Refer to Section 7-9-20/3 of the ABS *Rules for Survey After Construction (Part 7).*

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 4 PUMPS AND PIPING SYSTEMS

SECTION 2 PUMPS, PIPES, VALVES AND FITTINGS

3 Pressure Tests *(2002)*

(Revise Paragraph 4-4-2/3.15, as follows:)

3.15 Hydrostatic Tests of Shell Valves *(1 July 2018)*

All valves intended for installation on the side shell at or below the load waterline, including those at the sea chests, are to be hydrostatically tested before installation and in the presence of the Surveyor.

The valve housing of each valve is to be subjected to a pressure of not to be less than test pressure of 5 bar (5.1 kgf/cm^2, 72.5 psi). No leakage is permitted and holding time as follows:

- 15 seconds for sizes up to 50 mm (2 inch)
- 60 seconds for sizes 75 mm - 150 mm (2.5 inch - 6 inch)
- 120 seconds for sizes 200 mm - 300 mm (8 inch - 12 inch)
- 300 seconds for sizes 350 mm (14 inch) and larger

The valve assembly is to be subjected to a hydrostatic seat leakage test. The test is to be performed with closed valve with the other end open to atmosphere. The pressure is to be applied independently on each side. Test pressure is not to be less than 5 bar (5.1 kgf/cm^2, 72.5 psi). Holding time is 5 minutes for all sizes.

5 Metallic Pipes

(Revise Paragraph 4-4-2/5.8, as follows:)

5.8 Other Materials *(1 July 2018)*

Piping containing flammable fluids is to be constructed of steel or other materials approved by ABS. Other equivalent material with a melting point above 930°C (1706°F) and with an elongation above 12% may be accepted. Aluminum and aluminum alloys which are characterized by low melting points, below 930°C (1706°F), are considered heat sensitive materials and are not to be used to convey flammable fluids, except for such piping as arranged inside cargo tanks or heat exchangers or as otherwise permitted for engine, turbine and gearbox installations, see 4-2-1/7.7 of the *Steel Vessel Rules*.

On oil tankers and chemical tankers aluminized pipes are prohibited in cargo tanks, cargo deck tank area, pump rooms, cofferdams, or other areas where cargo vapor may accumulate. Aluminized pipes may be permitted in ballast tanks, in inerted cargo tanks, and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 4 PUMPS AND PIPING SYSTEMS

SECTION 4 FUEL OIL AND LUBRICATING OIL SYSTEMS AND TANKS

9 Lubricating Oil Systems

(Revise Paragraph 4-4-4/9.1, as follows:)

9.1 General *(1 July 2018)*

The lubricating systems are to be so arranged that they will function satisfactorily under the conditions specified in 4-1-1/17. Consideration is to be given to all acceptable fill levels in the lube oil sumps and tanks for compliance with this requirement.

The lubricating-oil piping is to be entirely separated from other piping systems. In addition, the requirements of 4-4-4/1.1.2, 4-4-4/1.3 and 4-4-4/1.5 are applicable.

The requirements in 4-4-4/3.7 are also applicable for lubricating-oil tanks. However, arrangements for remotely closing the valve from a position outside of the compartment need not be provided if inadvertent valve closure could result in damage to the running machinery due to lack of lubricating oil. Where the machinery is arranged for automatic shutdown upon loss of lubricating oil, the valve required by 4-4-4/3.7 is to be provided with means to close it from a readily accessible and safe location outside of the compartment in which the valve is located.

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 7 SHIPBOARD AUTOMATIC OR REMOTE CONTROL AND MONITORING SYSTEMS

SECTION 1 GENERAL

(Revise Subsection 4-7-1/1, as follows:)

1 Scope *(1 July 2018)*

The requirements contained in this section are intended for unrestricted vessels of under 90 m (295 ft) in length fitted with control and monitoring systems that embody various degrees of automatic or remote control and monitoring of the propulsion machinery and propulsion-machinery space. These requirements are in addition to those in other sections of the Rules. The following table indicates the applicability of the relevant requirements:

Vessel's Length (L)	*Gross Tonnage (GT)*			
	Under 500	*Under 500 assigned optional **ABCU-H** symbol (for TUG Vessels)*	*500 or over/not assigned optional **ACCU** or **ABCU** symbol*	*500 or over/assigned optional **ACCU** or **ABCU** symbol*
L < 20 m (65 ft)	Will be specially considered	—	Will be specially considered	—
20 m (65 ft) ≤ L ≤ 46 m (150 ft)	Use Section 4-7-6	Use Section 4-7-7	Use Sections 4-7-1 to 4-7-3	Use Section 4-7-4 or 4-7-5, as applicable
L > 46 m (150 ft)	Use Section 4-7-6	—	Use Sections 4-9-1 and 4-9-2 of the *Steel Vessel Rules*	Use Sections 4-9-1 to 4-9-9 of the *Steel Vessel Rules*, for **ACCU** or Sections 4-9-1 to 4-9-9 of SVR plus 4-7-5 for **ABCU** as applicable

Consideration will be given to vessels of special design such as surface effect vessels, air cushion vessels, etc., upon submission of manufacturer's specification and drawings.

3 Propulsion Class Notations *(1998)*

(Revise Paragraph 4-7-1/3.1, as follows:)

3.1 Vessels ≥ 500 GT and ≤ 46 m (150 ft) in Length *(1 July 2018)*

3.1.1 ACCU Notation

Automatic or remote control and monitoring systems complying with Section 4-7-4 will be distinguished in the *Record* by the notation **ACCU**.

3.1.2 ABCU Notation

Automatic or remote control and monitoring systems complying with Section 4-7-5 will be distinguished in the *Record* by the notation **ABCU**.

Notes:

1 **ACCU** or **ABCU** class notation may be granted to vessels of < 500 GT and a length of 20 m (65 ft) ≤ *L* ≤ 46 m (150 ft), provided that the applicable requirements in Sections 4-7-1 through 4-7-5 of this Chapter are met.

2 **ABCU-H** class notation may be granted to vessels of < 500 GT and a length of 20 m (65 ft) ≤ *L* ≤ 46 m (150 ft), for restricted operation in harbor, provided that the applicable requirements in Section 4-7-7 of this Chapter are met.

9 Tests and Surveys

(Revise Paragraph 4-7-1/9.3, as follows:)

9.3 Periodical Surveys *(1 July 2018)*

The continuance of **ACCU**, **ABCU** or **ABCU-H** certification is subject to periodic survey of the automatic or remote control and monitoring systems installation, as outlined in Chapter 8 of the ABS *Rules for Survey After Construction (Part 7).*

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 7 SHIPBOARD AUTOMATIC OR REMOTE CONTROL AND MONITORING SYSTEMS

SECTION 4 VESSELS CLASSED WITH ACCU NOTATION

(Revise heading and Item M1 in 4-7-4/Table 2, as follows:)

TABLE 2
Control Station in Navigation Bridge
(Applicable to All Classed Vessels) *(1 July 2018)*

Item			*Alarm (), 9)*	*Display (12)*	*Provisions of Device on Station (1)*	*Remarks*
Required for ACCU, ABCU or ABCU-H Classed Vessels						
Vital Auxiliary Pumps	M1	Start/stop and transfer switches			x	For **ABCU** or **ABCU-H** vessels having non-integrated propulsion machinery

(All other rows and notes remain unchanged.)

(Add new Section 4-7-7, as follows:)

PART 4 VESSEL SYSTEMS AND MACHINERY

CHAPTER 7 SHIPBOARD AUTOMATIC OR REMOTE CONTROL AND MONITORING SYSTEMS

SECTION 7 TOWING VESSELS LESS THAN 500 GT HAVING A LENGTH EQUAL OR GREATER THAN 20 M (65 FT) AND EQUAL OR LESS THAN 46 M (150 FT) CLASSED WITH ABCU-H NOTATION *(1 July 2018)*

1 General

The requirements in this Section apply to ABS classed towing vessels capable of operating with unmanned engine rooms limited to restricted operations in Harbor. These vessels can be assigned the optional notation **ABCU-H** provided they meet the requirements of this section. Except as noted herein, the requirements in Sections 4-7-1 through 4-7-3, as applicable, are to be complied with.

3 Equipment

Equipment associated with the remote or automatic control and monitoring of the propulsion machinery is to comply with the following requirements.

3.1 Equipment Tests

3.1.1 Prototype Environmental Testing

Prototype environmental tests specified in 4-7-2/Table 1 are to be conducted by the manufacturers. Acceptance will be based on review of the manufacturer's certified test reports by ABS. Omission of certain tests may be considered, taking into consideration the location of installation, functionality, contained devices, etc. of the equipment.

In general, field sensors (e.g., pressure transmitters), field devices (e.g., solenoid valves), circuit breakers and cables may be exempted from the tests specified in 4-7-2/Table 1.

For computer-based systems, the equipment to be tested includes microprocessors, storage devices, power supply units, signal conditioners, analog/digital converters, computer monitors (visual display units), and keyboards, but may exclude printer, data recording or logging devices not required by this section.

3.1.2 Type Approval Program

At the request of the manufacturer, equipment, subassemblies or complete assemblies of control, monitoring and safety systems may be considered for Type Approval in accordance with the provisions of 1-1-A3/5.3 (RQS) or 1-1-A3/5.5 (PQA) of the ABS *Rules for Conditions of Classification (Part 1)*. Where qualified, they may be listed on the ABS website as Type Approved Products.

For the updating or renewal of type approval, please refer to 1-1-A3/5.7.2 and 1-1-A3/5.7.4 of the ABS *Rules for Conditions of Classification (Part 1)*.

5 Station in Navigation Bridge

The navigation bridge propulsion control station is to include controls, displays and alarms as listed 4-7-4/Table 2 as applicable. Local indication of item C2 in 4-7-4/Table 2 may be accepted if a summary alarm is provided in the navigation bridge. The monitoring of diesel engines and support equipment is to be as listed in 4-7-7/Table 1 and 4-7-7/Table 2.

For vessels having nonintegrated propulsion machinery, the means for starting, stopping and transferring vital auxiliary pumps (see 4-7-4/15) are to be fitted at the station in the navigation bridge.

As an alternative, a summary-alarm for the propulsion and its associated machinery may be provided at the station in the navigation bridge. Any of the alarm conditions as listed in 4-7-7/Table 1 and 4-7-7/Table 2 are to activate the summary-alarm, as applicable.

7 Continuity of Power

The requirements in 4-7-4/13 are applicable.

9 Propulsion Diesel Engines

9.1 Lubricating Oil

In the event of loss of lubricating oil, there is to be an automatic shutdown of the main engine.

9.3 Overspeed

An overspeed condition is to cause the automatic shutdown of the main engine.

11 Electric Propulsion

For electric propulsion driven vessels, the specific requirements in 4-7-4/21 are to be complied with, as applicable.

13 Fire Protection and Firefighting Arrangements

The requirements in 4-7-6/15.1 are applicable. In addition, operation of a fire pump, including associated valves necessary to deliver the required capacity to the fire main, is to be provided in the navigation bridge. However, valves located near the pump need not be provided with remote operation from the navigation bridge if they are kept locked open (LO) or closed (LC), as appropriate, to provide immediate water supply to the fire main. The position of the valves (open or closed) is to be clearly marked. Where the sea chest valve is located in the same compartment as the fire pump and the sea chest valve is kept locked open, a high-level bilge alarm is to be fitted in the fire pump space. If the sea chest is located in a different space than the compartment containing the fire pump, then a high-level bilge alarm is to be fitted in the fire pump space, as well as the compartment containing the sea chest, in order to detect possible flooding in each of these spaces. The high-level bilge alarm is to sound in the navigation bridge.

15 Protection Against Flooding

The requirements in 4-7-6/15.3 is applicable.

17 Alarms and Displays

The following controls, alarms and displays are to be provided at the navigation bridge, as applicable.

TABLE 1
Monitoring of Propulsion Machinery –Diesel Engines *(1 July 2018)*

Item			*Alarm (1)*	*Display (9)*	*Automatic Start of Required Standby Vital Auxiliary Pump with Alarm (1)*	*Remarks (7)*
Fuel Oil System	A1	Leakage from high pressure pipes	x			
	A2	Fuel oil in daily service tank, level – low	x			See Note 10
Lube Oil System	B1	Lube oil pressure to main engine and reduction gear	x	Pressure	x	Automatic engine shutdown (2, 3)
	B2	Oil mist in crankcase, mist – concentration high; or Bearing temperature – high; or Alternative arrangements	x			Automatic engine shutdown (4)
Turbocharger	C1	Turbocharger lube oil inlet, pressure – low	x	Pressure		See Note 5, 10
	C2	Turbocharger oil outlet temp., each bearing – high	x	Temp.		See Note 8, 10
	C3	Speed	x	x		Alarm Activation for High Speed only required for turbochargers of categories B and C See note 10
Cylinder Fresh Cooling Water System	E1	Water outlet (general), temperature – high	x	Temp.		Automatic engine slowdown (6)
	E2	Cooling water in expansion tank, level – low	x			See Note 10
Air System	F1	Starting air, pressure – low	x			See Note 10
Scavenge Air System	G1	Scavenge air receiver, temperature – high	x			See Note 10
Engine	H1	Engine speed		Speed		
	H2	Engine overspeed	x			Automatic engine shutdown (2)
Power Supply	I1	Control, alarm or safety system, power supply failure	x			

Notes:

1 Required alarm or starting of standby pump is denoted by a (x).

2 Separate sensors are required for a) alarm/automatic starting of required standby pump, and b) automatic engine shutdown.

3 Automatic engine shutdown is to be alarmed and effected upon loss of oil pressure.

4 For engines having a power of 2250 kW (3000 hp) and above or having a cylinder bore of more than 300 mm (11.8 in.). Single sensor having two independent outputs for initiating alarm and for shutdown will satisfy for independence of alarm and shutdown. See 4-2-1/7.2 of the *Steel Vessel Rules*.

5 Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

6 Two separate sensors are required for alarm and slowdown.

7 Instead of automatic slowdown, manual slowdown will be acceptable, provided visual/audible alarm with illumination sign "Reduced Power" is located in the navigation bridge.

8 Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.

9 Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

10 A local indication of alarm may be accepted if a summary alarm in the navigation bridge station to alert operator is provided.

TABLE 2
Monitoring of Auxiliary Prime-movers and Electrical Generators *(1 July 2018)*

Item				*Alarm* *(1)*	*Display* *(2)*	*Remarks*
Diesel Engine	Lube Oil	A1	Pressure, lube oil inlet – low	x	Pressure	Automatic engine shutdown See Note 3
	Cooling Medium	B2	Temperature, outlet – high	x		See Note 3
		B3	Level, expansion tank – low	x		If separate from main system See Note 3
	Fuel Oil	C1	Fuel oil leakage from pressure pipe	x		See Note 3
		C2	Level, in fuel oil daily service tank – low	x		See Note 3
	Starting Medium	E1	Pressure or level – low	x	Pressure, or level	See Note 3
	Overspeed	F1	Device activated	x		Automatic shutdown. See Note 3
	Turbocharger	G1	High speed	x		Alarm Activation for High Speed only required for turbochargers of categories B and C
Electrical Generator		H1	Pressure, bearing, lube oil inlet – low	x	Pressure	Prime mover automatic shutdown See Note 3
		H2	Voltage – off-limits	x	Voltage	See Note 3
		H3	Frequency – off-limits	x	Frequency	See Note 3
		H4	Current – high	x	Current	See Note 3
		H5	Transfer of standby generator	x		

Notes:

1 Required alarm is denoted by a (x).

2 Display of the analog or digital signal for the monitored parameter. The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

3 A local indication of alarm may be accepted if a summary alarm in the navigation bridge to alert operator is provided.

19 Sea Trials

In addition to the trials required by 4-7-4/37, successful operation of the propulsion machinery is to be demonstrated with the propulsion-machinery space unattended for a period of at least 6 hours.