Part 3 Hull

Chapter 11 Hull equipment, supporting structure and appendages
FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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# CHANGES – CURRENT

This document supersedes the January 2017 edition of DNVGL-RU-SHIP Pt.3 Ch.11. Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

**Changes January 2018, entering into force as from date of publication**

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<tr>
<th>Topic</th>
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<tr>
<td>Modifications to rules for crane foundation</td>
<td>Sec.2 [4.1.8]</td>
<td>Increased bending moment due to heel and trim addressed.</td>
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<tr>
<td></td>
<td>Sec.2 [4.1]</td>
<td>The application is clarified.</td>
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<td></td>
<td>Sec.2 [4.5.2]</td>
<td>It's clarified for which equipment design load for life saving appliances shall apply.</td>
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<td></td>
<td>Sec.2 [4.6]</td>
<td>The acceptance criteria are modified and made more detailed by adding Sec.2 [4.6.3] and Sec.2 [4.6.4].</td>
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**Changes January 2018, entering into force 1 July 2018**

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<td>— Sec.1 [6.1] General design (Sec.1 [6.1.1] to Sec.1 [6.1.3])</td>
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<td>— Sec.1 [6.2] Materials (Sec.1 [6.2.1] to Sec.1 [6.2.3])</td>
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<td>— Sec.1 [6.3] Mechanical design (Sec.1 [6.3.1] to Sec.1 [6.3.6])</td>
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<td>— Sec.1 [6.4] Hydraulic system</td>
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<td>— Sec.1 [6.7] Marking</td>
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<td>Additional requirement</td>
<td>Sec.1 [6.3.4]</td>
<td>Additional requirements for power operated brakes and for manual operation of brake.</td>
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<td>Implementation of IACS UR A1</td>
<td>Sec.1 [1.3.1]</td>
<td>Guidance note updated with new environmental criteria.</td>
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<td></td>
<td>Sec.2 [2.2]</td>
<td>Paragraph added to align with UR A1.</td>
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<td></td>
<td>Sec.1 [3.1.1]</td>
<td>Definition of A updated and new figure for calculation of side projected area added.</td>
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<td>Sec.1 [4.5.1]</td>
<td>Paragraph modified to include anchors of all sizes for proof testing.</td>
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<td>Implementation IACS UR A2</td>
<td>Sec.1 [5.1.7]</td>
<td>Additional requirement for use of wire rope included.</td>
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<td>Sec.2 [5.1.5]</td>
<td>Modified paragraphs to include &quot;other&quot; towing, in line with UR A2.</td>
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<td>Sec.2 [5.1.8]</td>
<td>Added new paragraph to define requirements for supporting structure and shipboard fittings.</td>
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<td>Sec.2 [5.1]</td>
<td>Added new paragraphs to define applicability of the subsection in line with UR A2.</td>
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<td>Sec.2 [5.3.1]</td>
<td>Modified paragraph to include new requirements for shipboard fittings selected from an industry standard and to include &quot;other&quot; towing.</td>
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<td>Sec.2 [5.3.2]</td>
<td>Modified paragraph to include new requirements for shipboard fittings not selected from an industry standard.</td>
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<td>Modified text to align with UR A2.</td>
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<td>Sec.2 [5.4.3]</td>
<td>Added figure showing sample arrangement, added text about alignment.</td>
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<td>Sec.2 [5.4.4]</td>
<td>Added minimum requirement for the attachment point height and corresponding figures.</td>
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<td>Sec.2 [5.4]</td>
<td>Added paragraph referring to design loads.</td>
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<td>Modified requirement for design load for mooring operations, &quot;other&quot; towing included.</td>
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<td>Sec.2 [5.5.2]</td>
<td>Modified paragraph to define maximum brake holding load.</td>
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<td>Modified text to align with UR A2, added new figure.</td>
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<td>New paragraph added for requested higher SWL/TOW.</td>
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<td>Subsection modified to be applicable for assessment with beam theory or grillage analysis. New paragraph inserted to include FE analysis.</td>
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<td>Added new paragraph to include additional requirements for towing and mooring arrangement.</td>
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<td>Sec.2 [5.7]</td>
<td>Title changed to include TOW, paragraph added about TOW.</td>
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<td>Sec.2 [5.8]</td>
<td>New sub-section on corrosion addition and wear allowance added to align with UR A2.</td>
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<td>New paragraph regarding welding, welding procedures and welders.</td>
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<td>Sec.1 [6.3.1]</td>
<td>Former paragraph [6.1.5]. Requirements regarding stresses in torque-transmitting components added.</td>
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<td>Sec.1 [6.3.1]</td>
<td>Additional requirement regarding anchorage depth deeper than 82.5 m.</td>
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<td>Sec.1 [6.3.1]</td>
<td>&quot;Guidance note&quot; regarding anchor masses, normal lifting forces and hawse pipe efficiency added.</td>
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<td>Sec.1 [6.3.2]</td>
<td>Former paragraph [6.1.5]. Requirements regarding dynamic effects of sudden stopping and starting of the prime mover added.</td>
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<td>Sec.1 [6.3.3]</td>
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<td>Requirements regarding protection of mechanical parts added, i.e. overload protection. Also protection system to limit speed of prime mover required.</td>
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<td>Requirements regarding means to contain debris added.</td>
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<td>Subsection regarding hydraulic systems added.</td>
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<td>Former subsection [6.3.2]. Requirements regarding acceptance tests added.</td>
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<td>Former subsection [6.3.3]. Requirements regarding testing added.</td>
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<td>Sec.1 [6.7]</td>
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<td>Subsection regarding &quot;marking&quot; added.</td>
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<td>Guidance note added for securing of stowed anchors.</td>
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<tr>
<td>Sec.1 [1.3.3]</td>
<td></td>
<td>New subsection describing guidance for mooring lines for ships EN &gt; 2000 added.</td>
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<td>Additional requirement for use of wire rope included.</td>
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<td>Sec.1 Table 1</td>
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<td>Sec.1 Table 1 modified for ships with EN up to 2000 with respect to mooring lines minimum breaking strength, new notes added to the table regarding mooring lines. Values for mooring lines for ships with EN &gt; 2000 deleted from Table 1.</td>
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<td>Sec.1 Table 2</td>
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<td>Sec.1 Table 2 modified with respect to mooring lines, to align with IACS Rec.10.</td>
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<td>Sec.3 [2.2.5]</td>
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<td>The requirement w.r.t. maximum distance between bulwark stay of 2 m is not required by Load Line. Alternative solutions with larger distance may be accepted based on special consideration.</td>
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## Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.
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SECTION 1 ANCHORING, MOORING AND TOWING EQUIPMENT

Symbols
For symbols not defined in this section, see Ch.1 Sec.4.

1 General

1.1 Introduction

1.1.1 The requirements given in this section apply to equipment and installation for anchoring, mooring and towing.

1.1.2 Towlines and mooring lines are not subject to classification. Lengths, breaking strength and number of mooring lines are, however, given in the equipment tables as guidance.

1.2 Documents and certificates to be submitted
The documents and certificates to be submitted are specified in Ch.1 Sec.3.

1.3 Assumptions for anchoring equipment

1.3.1 The anchoring equipment required is the minimum considered necessary for temporary mooring of a vessel in moderate sea conditions when the vessel is awaiting berth, tide, etc. The equipment is therefore not designed to hold a vessel off fully exposed coasts in rough weather or for frequent anchoring operations in open sea. In such conditions the loads on the anchoring equipment will increase to such a degree that its components may be damaged or lost owing to the high energy forces generated. The class notation DWA provides additional requirements for ships intended for regular anchoring at deep water, see Pt.6 Ch.5 Sec.17.

Guidance note:
If the intended service of the vessel is such that frequent anchoring in open sea is expected, it is advised that the size of anchors and chains is increased above the rule requirements, taking into account the dynamic forces imposed by the vessel moving in heavy seas. The equipment number (EN) formulae for anchoring equipment are based on an assumed maximum current speed of 2.5 m/s, maximum wind speed of 25 m/s and a minimum scope of chain cable of 6, the scope being the ratio between length of chain paid out and water depth. For vessels with length greater than 135 m, alternatively the required anchoring equipment can be considered applicable to a maximum current speed of 1.54 m/s, a maximum wind speed of 11 m/s and waves with maximum significant height of 2 m.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.2 The anchoring equipment required by the rules 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.

1.3.3 It is assumed that under normal circumstances the vessel uses only one bower anchor and chain cable at a time.
2 Structural arrangement for anchoring equipment

2.1 General

2.1.1 The anchors shall normally be housed in hawse pipes of suitable size and form to prevent movement of anchor and chain due to wave action.

The arrangements shall provide an easy lead of the chain cable from the windlass to the anchors. Upon release of the brake, the anchor is immediately to start falling by its own weight. At the upper and lower ends of hawse pipes, there shall be chafing lips. There shall be well rounded parts at the upper and lower ends of the hawse pipes, anchor pocket or bell mouth in those areas where the chain cable is supported during paying out and hoisting and when the vessel is laying at anchor. Alternatively, roller fairleads of suitable design may be fitted.

Where hawse pipes are not fitted alternative arrangements will be specially considered.

Guidance note:
Concerning securing of stowed anchors.
To hold the anchor tight in against the hull or the anchor pocket, respectively, it is recommended to fit anchor lashings, e.g. a 'devil's claw'. Anchor lashings should be designed to resist a load at least corresponding to twice the anchor mass plus 10 m of cable without exceeding 40% of the yield strength of the material.

2.1.2 The shell plating in way of the hawse pipes shall be increased in thickness and the framing reinforced as necessary to ensure a rigid fastening of the hawse pipes to the hull.

Guidance note:
The diameter ratio, \( \frac{D_c}{d_c} \), between the curvature, \( D_c \), of the rounded parts at lower end of anchor pocket, hawse pipe or bell mouth and the anchor chain cable diameter, \( d_c \), shall be minimum 6.

2.1.3 Ships provided with a bulbous bow, and where it is not possible to obtain ample clearance between shell plating and anchors during anchor handling, local reinforcements of the bulbous bow shall be provided as necessary.

2.1.4 The chain locker shall have adequate capacity and a suitable form to provide a proper stowage of the chain cable, and an easy direct lead for the cable into the spurling pipes, when the cable is fully stowed. Port and starboard cables shall have separate spaces. If three (3) bower anchors and three (3) hawse pipes are used, there shall be three (3) separate spaces. Spurling pipes and chain lockers shall be watertight up to the weather deck.

Guidance note:
Bulkheads separating adjacent chain lockers need not be watertight.

Where means of access are provided, they shall be closed by a substantial cover and secured by closely spaced bolts.

Where means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements shall be in accordance with recognized standards (see guidance note 3 below) or equivalent for watertight manhole covers. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

Spurling pipes through which anchor cables are led shall be provided with permanently attached closing appliances to minimize water ingress. Adequate drainage facilities of the chain locker shall be adopted. (IACS UR L4 Rev. 3)
Guidance note 1:
The spurling pipe is the pipe between the chain locker and the weather deck.
---end of guidance note---

Guidance note 2:
The emergency release of the chain dead end should be arranged watertight or above the weather deck.
---end of guidance note---

Guidance note 3:
Concerning permanently attached appliances.
Examples of the recognized standards are such as:
  i) ISO 5894-1999
  ii) China: GB 11628-1989, Ship Manhole Cover
  iii) India: IS 15876-2009, Ships and Marine Technology manholes with bolted covers
  iv) Japan: JIS F2304, Ship’s Manholes and JIS F2329, Marine Small Size Manhole
  v) Korea: KSV 2339:2006 and KS VISO5894
  vi) Norway: NS 6260:1985 to NS 6266:1985
---end of guidance note---

2.1.5 Provisions shall be made for securing the inboard ends of chain to the structure. This attachment shall be able to withstand a force of not less than 15% nor more than 30% of the minimum breaking strength of the chain cable. The fastening of the chain to the ship shall be made in such a way that in case of emergency when anchor and chain shall be sacrificed, the chain can be readily released from an accessible position outside the chain locker. For recognized standards, see guidance note.

Guidance note 1:
Concerning standards for cable end connections.
Examples of the recognized standards are such as:
  i) DIN 81860
  ii) CB/T 3143-1999
  iii) JIS F2025.
---end of guidance note---

3 Equipment specification

3.1 Equipment number

3.1.1 Equipment number for anchors and chain cables
The equipment number is given by the formula:

\[ EN = \Delta^{2/3} + 2BH + 0.1A \]

where:

\[ H = \text{effective height in m from the summer load waterline to the top of the uppermost deckhouse, to be measured as follows:} \]
\[ H = a + \Sigma h_i \]

\[ a = \text{distance in m from summer load waterline amidships to the upper deck at side} \]
\( h_i \) = height in m on the centreline of each tier of houses having a breadth greater than \( B/4 \). For the lowest tier, \( h_i \) shall be measured at centreline from the upper deck, or from a notional deck line where there is local discontinuity in the upper deck, see below Figure 1 for an example

\( A \) = side projected area in \( m^2 \), of the hull, superstructures and houses above the summer load waterline, which is within \( L \) of the ship. Houses of breadth of \( B/4 \) or less shall be disregarded.

In the calculation of \( \Sigma h_i \) and \( A \) sheer and trim shall be ignored.

**Figure 1 Side projected area**

Windscreens or bulwarks more than 1.5 m in height shall be regarded as parts of superstructures and of houses when determining \( H \) and \( A \).

For bulwarks more than 1.5 m high, the area \( A_2 \) shown in Figure 2 below, shall be included when calculating \( A \).

Guidance note:
According to IACS UR A1, the height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining \( H \) and \( A \).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

### 3.1.2 Equipment number for towline and mooring lines

The equipment number for guidance on selection of towline and mooring lines as well as for the determination of the design load for shipboard towing and mooring equipment and supporting hull structure shall be determined according to [3.1.1] applying the following area:

\[ A = \text{side projected area in } m^2, \text{ of the hull, superstructures and houses, as defined in [3.1.1], including deck cargo as given by the loading manual.} \]
Figure 2 Bulwark area
### Table 1 Equipment, general

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<th>Mass per anchor kg</th>
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<th>Mooring lines 1,2,4 (guidance)</th>
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<td>Towl ine (guidance)</td>
<td>Mooring lines (guidance)</td>
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<td>Minimum length m</td>
<td>Minimum breaking strength kN Number</td>
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<td>23000</td>
<td>770</td>
<td>132</td>
<td>117</td>
</tr>
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</table>
### 3.2.1 The equipment shall in general be in accordance with the requirements given in Table 1.

The two bower anchors and their cables shall be connected and stowed in position ready for use. The total length of chain cable required shall be equally divided between the two anchors.

The towline and the mooring lines are given as guidance only, representing a minimum standard, and shall not be considered as conditions of class.

**Guidance note:**

If anchor chain total length is an uneven number of shackles, no more than one standard shackle (27.5 m) difference in length is allowed between the two anchors.

---end---of---guidance---note---
3.2.2 For fishing vessels the equipment shall be in accordance with the requirements given in Table 2. When the equipment number is larger than 720, Table 1 shall be applied.

3.2.3 For ships with restricted service the equipment specified in Table 1 and Table 2 may be reduced in accordance with Table 3. No reductions are given for class notations R0 and R1.

3.2.4 For ships with equipment number \( EN \) less than 205 and fishing vessels with \( EN \) less than 500 the anchor and chain equipment specified in Table 1 and Table 2 may be reduced, based upon a special consideration of the intended service area of the vessel. The reduction shall not be more than given for the service notation R4 in Table 3. In such cases a minus sign will be given in brackets after the equipment letter for the vessel, e.g. f(–).

### Table 2 Equipment for fishing vessels

<table>
<thead>
<tr>
<th>Equipment number</th>
<th>Equipment letter</th>
<th>Stockless bower anchors</th>
<th>Stud-link chain cables</th>
<th>Towline (guidance)</th>
<th>Mooring lines (guidance)</th>
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<tr>
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<td>Number</td>
<td>Number</td>
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<td>Diameter and</td>
<td>Minimum breaking strength kN</td>
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<td></td>
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<td>VL K1 mm</td>
<td>VL K2 mm</td>
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<td></td>
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</tr>
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<td>100</td>
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### Table 3 Equipment reductions for service restriction notations (see Table 2)

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<tr>
<td>R3</td>
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</tr>
<tr>
<td>R4</td>
<td>2</td>
<td>−30%</td>
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<tr>
<td>RE</td>
<td>2</td>
<td>−40%</td>
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</table>

Alternatively:

<table>
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<th>Stockless bower anchors</th>
<th>Stud-link chain cables</th>
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<tr>
<td>R4</td>
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<td>No change</td>
</tr>
<tr>
<td>RE</td>
<td>1</td>
<td>−20%</td>
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</tbody>
</table>

### 3.3 Mooring lines for ships with \( EN > 2000 \)

3.3.1 The minimum recommended strength and number of mooring lines for ships with an equipment number \( EN > 2000 \) are given in [3.3.4] and [3.3.5], respectively.

3.3.2 The following is defined with respect to the purpose of mooring lines, see also Figure 3:

- breast line is a mooring line that is deployed perpendicular to the ship, restraining the ship in the off-berth direction
- spring line is a mooring line that is deployed almost parallel to the ship, restraining the ship in fore or aft direction
- head/stern line is a mooring line that is oriented between longitudinal and transverse direction, restraining the ship in the off-berth and in fore or aft direction. The amount of restraint in fore or aft and off-berth direction depends on the line angle relative to these directions.
3.3.3 The strength of mooring lines and the number of head, stern, and breast lines for ships with an equipment number $EN > 2000$ shall be based on the side projected area $A_1$. Side projected area $A_1$ shall be calculated similar to the side projected area $A$ according to [3.1.1] but considering the following conditions:

— For oil tankers, chemical tankers, bulk carriers, and ore carriers the lightest ballast draft shall be considered for the calculation of the side-projected area $A_1$. For other ships the lightest draft of usual loading conditions shall 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 mean loading conditions as given by the trim and stability booklet that shall be expected to regularly occur during operation and, in particular, excluding light weight conditions, propeller inspection conditions, etc.

— Wind shielding of the pier can be considered for the calculation of the side-projected area $A_1$ unless the ship is intended to be regularly moored to jetty type piers. A height of the pier surface of 3 m over waterline may be assumed, i.e. the lower part of the side-projected area with a height of 3 m above the waterline for the considered loading condition may be disregarded for the calculation of the side projected area $A_1$.

— Deck cargo as given by the loading manual shall 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 shall be chosen as side projected area $A_1$.

Guidance note 1:
The mooring lines are based on a maximum current speed of 1.0 m/s and the following maximum wind speed $v_w$, in m/s:

$ v_w = 25.0 - 0.002 \left( A_1 - 2000 \right) $, for passenger ships, ferries, and car carriers with $2000 \, m^2 < A_1 \leq 4000 \, m^2$

$v_w = 21.0$, for passenger ships, ferries, and car carriers with $A_1 > 4000 \, m^2$

$v_w = 25.0$, for other ships.

---end---of---guidance---note---

Guidance note 2:
The wind speed is considered representative of a 30 second mean speed from any direction and at a height of 10 m above the ground. The current speed is considered representative of the maximum current speed acting on bow or stern ($\pm 10^\circ$) and at a depth of one-half of the mean draft. Furthermore, it is considered that ships are moored to solid piers that provide shielding against cross current.

---end---of---guidance---note---

Guidance note 3:
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 unbeficial mooring layouts can considerably increase the loads on single mooring lines.

---end---of---guidance---note---
3.3.4 Minimum breaking strength

The minimum breaking strength, in kN, of the mooring lines shall be taken as:

\[ MBL = 0.1 \cdot A_1 + 350 \]

The minimum breaking strength may be limited to 1275 kN (130 t). However, in this case the moorings shall be considered as not sufficient for environmental conditions given by [3.3]. For these ships, the acceptable wind speed \( v_{w*} \), in m/s, can be estimated as follows:

\[ v_{w*} = v_w \cdot \sqrt{\frac{MBL*}{MBL}} \]

where \( v_w \) is the wind speed as per [3.3.3], \( MBL* \) the breaking strength of the mooring lines intended to be supplied and \( MBL \) the breaking strength as recommended according to the above formula. However, the minimum breaking strength shall not be taken less than corresponding to an acceptable wind speed of 21 m/s:

\[ MBL* \geq \left( \frac{21}{v_w} \right)^2 \cdot MBL \]

If lines are intended to be supplied for an acceptable wind speed \( v_{w*} \) higher than \( v_w \) as per [3.3.3], the minimum breaking strength shall be taken as:

\[ MBL* = \left( \frac{v_{w*}}{v_w} \right)^2 \cdot MBL \]

3.3.5 Number of mooring lines

The total number of head, stern and breast lines shall be taken as:

\[ n = 8.3 \cdot 10^{-4} \cdot A_1 + 6 \]

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

\[ n = 8.3 \cdot 10^{-4} \cdot A_1 + 4 \]

The total number of head, stern and breast lines shall 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, \( MBL* \), shall 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 \( n* \) is the increased or decreased total number of head, stern and breast lines and \( n \) the number of lines for the considered ship type as calculated by the above formulas without rounding.

Vice versa, 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 shall be taken not less than:

- two lines where \( EN < 5000 \)
- four lines where \( EN \geq 5000 \).

The strength of spring lines shall 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 shall be likewise increased, but rounded up to the nearest even number.
4 Anchors

4.1 General

4.1.1 Anchor types dealt with are:
— ordinary stockless bower anchor
— ordinary stocked bower anchor
— H.H.P. (high holding power) anchor
— S.H.H.P. (super high holding power) anchor.

4.1.2 The mass of ordinary stockless bower anchors shall not be less than given in [3]. The mass of individual anchors may vary by 7% of the table value, provided that the total mass of anchors is not less than what is required for anchors of equal mass.

The mass of the head of stockless bower anchors including pins and fittings shall not be less than 60% of the table value.

4.1.3 The mass of stocked bower anchor, the stock not included, shall not be less than 80% of the table-value for ordinary stockless bower anchors. The mass of the stock shall be 25% of the total mass of the anchor including the shackle, etc., but excluding the stock.

4.1.4 A 'high holding power' anchor is an anchor with a holding power of at least twice that of an ordinary stockless anchor of the same mass. A H.H.P. anchor shall be suitable for ship's use and shall not require prior adjustment or special placement on the sea bottom.

4.1.5 For anchors approved as H.H.P. anchors, the mass shall not be less than 75% of the requirements given in [3]. In such cases the letter r will follow the equipment letter.

4.1.6 A 'super high holding power' anchor is an anchor with a holding power of at least four times that of an ordinary stockless anchor of the same mass. A S.H.H.P. anchor is suitable for restricted service ships' use and does not require prior adjustment or special placement on the sea bottom.

4.1.7 For anchors approved as S.H.H.P. anchors, the mass shall not be less than 50% of the requirements given in [3]. In such cases the letter rs will follow the equipment letter.

4.1.8 The use of S.H.H.P. anchors is limited to vessels with service restriction notation R1 or stricter.

4.1.9 The S.H.H.P. anchor mass shall not exceed 1500 kg.

4.2 Materials

4.2.1 Anchor heads may be cast, forged or fabricated from plate materials. Shanks and shackles may be cast or forged.

4.2.2 The materials shall comply with relevant requirements given in Pt.2.
Plate material in welded anchors shall be of the grades as given in Table 11.

4.2.3 Anchors made of nodular cast iron may be accepted in small dimensions subject to special approval of the manufacturer.

4.2.4 Fabricated anchors shall be manufactured in accordance with approved welding procedures using approved welding consumables and carried out by qualified welders.
4.3 Anchor shackle

4.3.1 The diameter of the shackle leg, in mm, shall normally not be less than:

\[ d_s = 1.4 \, d_c \]

where:

\[ d_c = \text{required diameter, in mm, of stud chain cable with tensile strength equal to the shackle material, see Table 1 or Table 2. For shackle material different from the steel grades VL K1, VL K2 and VL K3, linear interpolation between table values of } d_c \text{ will normally be accepted.} \]

4.3.2 The diameter of the shackle pin shall normally not be less than the greater of:

\[ d_p = 1.5 \, d_c \]
\[ d_p = 0.7 \, \ell_p \]

where:

\[ d_c = \text{as given in [4.3.1]} \]
\[ \ell_p = \text{free length of pin, in mm. It is assumed that materials of the same tensile strength are used in shackle body and pin. For different materials } d_p \text{ will be specially considered.} \]

4.4 Manufacturing

4.4.1 If not otherwise specified on standards or on drawings demonstrated to be appropriate, the following assembly and fitting tolerance shall be applied.

The clearance either side of the shank within the shackle jaws shall be no more than 3 mm for small anchors up to 3 tonnes weight, 4 mm for anchors up to 5 tonnes weight, 6 mm for anchors up to 7 tonnes weight and shall not exceed 12 mm for larger anchors.

The shackle pin shall be a push fit in the eyes of the shackle, which shall be chamfered on the outside to ensure a good tightness when the pin is clenched over on fitting. The shackle pin to hole tolerances shall be no more than 0.5 mm for pins up to 57 mm and 1.0 mm for pins of larger diameter.

The trunnion pin shall be a snug fit within the chamber and be long enough to prevent horizontal movement. The gap shall be no more than 1% of the chamber length.

The lateral movement of the shank shall not exceed 3 degrees, see Figure 4.

4.4.2 Securing of the anchor pin, shackle pin or swivel nut by welding shall be done in accordance with a qualified welding procedure.

4.5 Testing

4.5.1 Anchors of all sizes shall be proof tested with the test loads stipulated in Table 4.

4.5.2 The proof test load shall be as given in Table 4, dependent on the mass of equivalent anchor, defined as follows:

- total mass of ordinary stockless anchors
- mass of ordinary stocked anchors excluding the stock
- 4/3 of the total mass of H.H.P. anchors
— two (2) times of the total mass of S.H.H.P. anchors.
For intermediate values of mass the test load shall be determined by linear interpolation.

Figure 4 Allowable lateral movement of shank

4.5.3 The proof load shall be applied on the arm or on the palm at a distance from the extremity of the bill equal to 1/3 of the distance between it and the centre of the crown. The anchor shackle may be tested with the anchor.

4.5.4 For stockless anchors, both arms shall be tested simultaneously, first on one side of the shank and then on the other side.
For stocked anchors, each arm shall be tested individually.

4.5.5 The anchors shall withstand the specified proof load without showing signs of defects.
This shall be confirmed by visual inspection and NDT after proof load testing. For all types of anchor castings, all surfaces shall be checked by magnetic particle testing (MT) or penetrant testing (PT). All cast steel anchors shall be examined by ultrasonic testing (UT) in way of areas where feeder heads and risers have been removed and where weld repairs have been carried out. The welds of fabricated anchors shall be subject to MT. At sections of high load or at suspect areas, volumetric non-destructive examination, e.g., ultrasonic inspection or radiographic inspection, may be imposed.
Method and acceptance criteria shall follow the requirements for steel castings given in Pt.2.
4.5.6 Additional tests of the S.H.H.P. anchor may be required. These tests include the hammering test and the drop test, and are usually applied to cast steel anchors.

4.5.7 In every test the difference between the gauge lengths (as shown in Figure 5) where one-tenth of the required load was applied first and where the load has been reduced to one-tenth of the required load from the full load may be permitted not to exceed one percent (1%).

![Figure 5 Gauge length](image)

**Figure 5 Gauge length**

4.6 Additional requirements for H.H.P. and S.H.H.P. anchors

4.6.1 H.H.P. and S.H.H.P. anchors shall be designed for effective hold of the sea bed irrespective of the angle or position at which they first settle on the sea bed after dropping from a normal type of hawse pipe. In case of doubt a demonstration of these abilities may be required.

4.6.2 The design approval of H.H.P. and S.H.H.P. anchors is normally given as a type approval.

4.6.3 H.H.P. anchors for which approval is sought shall be tested on sea bed to show that they have a holding power per unit of mass at least twice that of an ordinary stockless bower anchor. The mean value of three tests, for each anchor and nature of sea bed, see [4.6.8], shall form the basis for holding power.

4.6.4 S.H.H.P. anchors for which approval is sought shall be tested on sea bed to show that they have a holding power per unit of mass at least four (4) times that of an ordinary stockless bower anchor. The mean value of three tests, for each anchor and nature of sea bed, see [4.6.8], shall form the basis for holding power.

4.6.5 If approval is sought for a range of H.H.P. anchor sizes, at least two sizes shall be tested. The mass of the larger anchor to be tested shall not be less than 1/10 of that of the largest anchor for which approval is sought. The smaller of the two anchors to be tested shall have a mass not less than 1/10 of that of the larger.

4.6.6 If approval is sought for a range of S.H.H.P. anchor sizes, at least three sizes shall be tested, indicative of the bottom, middle and top of the mass range.

4.6.7 Each test shall comprise a comparison between at least two anchors, one ordinary stockless bower anchor and one H.H.P. or S.H.H.P. anchor. The two anchors selected for testing shall be of approximately the same mass and tested in association with the size of chain required for that anchor mass. Where an ordinary stockless anchor is not available, for testing of H.H.P. anchors a previously approved H.H.P. anchor may be used in its place. For testing of S.H.H.P. anchors, a previously approved H.H.P. or S.H.H.P. anchor may be used in place of an ordinary stockless anchor. The length of the cable with each anchor shall be such that the
pull on the shank remains horizontal. For this purpose a scope of 10 is considered normal but a scope of not less than 6 may be accepted. Scope is defined as the ratio of length of cable to depth of water.

4.6.8 The tests shall be conducted on at least three (3) different types of bottom, which normally shall be: soft mud or silt, sand or gravel, and hard clay or similar compacted material.

4.6.9 The tests shall normally be carried out by means of a tug. The pull shall be measured by dynamometer or determined from recently verified curves of the tug’s bollard pull as function of propeller r.p.m.

The diameter of the chain cables connected to the anchors shall be as required for the equipment letter in question. During the test the length of the chain cable on each anchor shall be sufficient to obtain an approximately horizontal pull on the anchor. Normally, a horizontal distance between anchor and tug equal to 10 times the water depth will be sufficient.

4.7 Identification

4.7.1 The following marks shall be stamped on one side of the anchor:

— mass of anchor (excluding possible stock)
— H.H.P., when approved as high holding power anchor
— S.H.H.P., when approved as super high holding power anchor
— certificate number
— date of test
— the Society’s stamp
— manufacturer’s mark
— additionally the unique cast identification shall be cast on the shank and the fluke.
Table 4 Proof loads for anchors

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5 Anchor chain cables

5.1 General requirements

5.1.1 Chain cables and accessories shall be designed according to a recognized standard, such as ISO 1704. A length of chain cable shall measure not more than 27.5 m and shall comprise an odd number of links. Where designs do not comply with this, drawings giving details of the design shall be submitted for approval.

5.1.2 The form and proportion of links and accessories together with examples of connections of links, shackles and swivels are shown in Figure 6. Other design solutions, e.g. short link chain cable or steel wire rope may be accepted after special consideration.

5.1.3 The diameter of stud link chain cable shall not be less than given in [3].

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DNV GL AS
If ordinary short link chain cable is accepted instead of stud link chain cable at least the same proof load will normally be required. For fishing vessels with equipment number $EN \leq 110$, the diameter shall be at least 20% in excess of the table value for the chain grade used.

5.1.4 Chain grade VL K1 shall normally not be used in association with H.H.P. or S.H.H.P. anchors.

5.1.5 Chain grade VL K3 shall not be used for chain diameter less than 20.5 mm.

5.1.6 Ships equipped with chain cable grade VL K2 or VL K3 will have the letters s or sh, respectively, added to the equipment letter.

5.1.7 Steel wire rope instead of stud link chain cable may be accepted for vessels with length less than 40 m, for vessels of special design or operation, for vessels with restricted services and for fishing vessels. The acceptance will be based on a case-by-case evaluation, including consideration of operational and safety aspects. If steel wire rope is accepted, the following shall be fulfilled:

— their strength shall be equal to that of tabular chain cable of grade VL K1, see Table 6
— a length of chain cable shall be fitted between the anchor and the steel wire rope. The length shall be taken as the smaller of 12.5 m and the distance between the anchor in stowed position and the winch
— the anchor weight shall be increased by 25%
— the length of the steel wire rope shall be at least 50% above the table value for the chain cable
— all surfaces being in contact with the wire shall be rounded with a radius of not less than 10 times the wire rope diameter (including stem)
— a corresponding note to be entered into the appendix to classification certificate.

Arrangements applying the steel wire ropes of trawl winches may be accepted, provided the strength of the rope is sufficient.
Figure 6 Standard dimensions of stud link chain cable and examples of connections, where rule diameter of chain cables is $D = d_c$. 
5.2 Materials and manufacture

5.2.1 Chain cables shall be made by manufacturers approved by the Society for the pertinent grade of chain cable, size and method of manufacture. Steel forgings and castings for accessories shall be made by manufacturers approved by the Society for the pertinent type of steel.

5.2.2 Stud link chain cables shall be manufactured by flash butt welding or, in the case of grade VL K2 and 3 chain cables, drop forging or casting. Pressure butt welding may also be approved for grade VL K1 and 2 short link chain cables provided that the nominal diameter of the chain cable does not exceed 26 mm.

5.2.3 Bar material for chain cables shall be in accordance with Pt.2 Ch.2 Sec.7. Studs for chain cable links shall be made of forged or cast steel. The carbon content in stud materials shall not exceed 0.25% if studs shall be welded into the links.

5.2.4 Where studs are welded into the links this shall be completed before the chain cable is heat treated. Stud welds shall be made by qualified welders or operators using an approved procedure and low hydrogen consumables or processes. The stud ends shall have a good fit inside the link and the weld shall be confined to the stud end opposite the flash butt weld. The full periphery of the stud end shall be welded unless otherwise approved.

5.2.5 Accessories such as shackles and swivels shall be made of forged or cast steel in accordance with the general requirements given in Pt.2 Ch.2 Sec.6 or Pt.2 Ch.2 Sec.8, as appropriate. Tapered locking pins for detachable components shall be made of stainless or tinned steel with a lead stopper at the thick end.

5.3 Heat treatment

5.3.1 Chain cables and accessories shall be supplied in one of the conditions given in Table 5. Where alternative conditions are permitted, the manufacturer shall supply chain cables and accessories only in those conditions for which he has been approved.

5.3.2 When heat treating in batch furnaces, links shall be stretched out or otherwise suitably arranged to ensure uniform heating and cooling.

Table 5 Condition of supply for chain cables and accessories

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</tr>
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</table>

NA = not applicable

¹ VL K2 chain cables made by forging or casting shall be supplied in the normalised condition.
5.4 Proof load testing

5.4.1 Each length of chain cable and all accessories shall be proof load tested in the condition of supply and shall withstand the proof load specified in Table 6 or Table 7 without fracture. Accessories shall be subjected to the proof load prescribed for the chain cable grade and size for which they are intended.

5.4.2 If one link fails during testing, the defective link shall be removed and replaced by a connecting link of an approved type and the proof test again applied. In addition it shall be determined by examination that the probable cause of failure is not present in any of the remaining links. If a second link fails, the length shall be rejected.

5.4.3 If an accessory fails, it shall be rejected. In addition it shall be determined by examination that the probable cause of failure is not present in any of the remaining items.

5.5 Breaking load testing

5.5.1 Samples of chain cables and accessories shall be breaking load tested in the condition of supply and shall withstand the breaking load specified in Table 6 or Table 7. Accessories shall be subjected to the breaking load prescribed for the chain cable grade and size for which they are intended. End links and enlarged links need not be tested provided that they are manufactured and heat treated with the chain cable. It will be considered acceptable if the samples show no sign of fracture after application of the minimum specified load for 30 seconds.

5.5.2 For chain cables, one sample consisting of at least three links shall be taken at the frequency given in [5.5.3]. Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that:

— each sample is properly identified with the chain represented, and
— each sample is securely attached to and heat treated with the chain represented.

5.5.3 For flash butt welded or drop forged chain cables, one sample shall be taken from every four lengths of 27.5 m or less. For cast link chain cables, one sample shall be taken from each heat treatment charge with a minimum of one from every four lengths of 27.5 m or less.

5.5.4 For accessories, one sample item out of every test unit (batch) shall be taken. A test unit shall consist of up to 25 items, or up to 50 in the case of Kenter shackles, of the same accessory type, grade, size and heat treatment procedure. The test unit need not necessarily be representative of each heat of steel, heat treatment charge or individual purchase order.

5.5.5 Except as provided in [5.5.6], accessories that have been breaking load tested shall be discarded and not used as part of an outfit.

5.5.6 Accessories that have been breaking load tested may be used as part of an outfit provided that:

— the accessory is of higher grade than the chain cable for which it is intended, e.g. grade 3 accessory of grade 2 size in grade 2 chain, or
— the accessory is specially approved and designed with increased dimensions so that the breaking strength is not less than 1.4 times the break load of the chain cable for which it is intended.

5.5.7 The Society may waive the breaking load test of accessories provided that:

— the breaking load test has been completed satisfactorily during approval testing of the same type of accessory, and
— the tensile and impact properties of each manufacturing batch, see [5.5.10], are proved, and
— the accessories are subjected to suitable non-destructive testing.
5.5.8 For the purpose of waiving the breaking load test of accessories, a manufacturing batch (test unit) shall consist of up to 25 items, or up to 50 in the case of Kenter shackles, of the same type, grade, size and heat treatment charge. The test unit need not necessarily be representative of each heat of steel or individual purchase order.

Table 6 Proof and breaking loads for stud link chain cables and accessories

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<th>Chain cable diameter mm</th>
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5.5.9 If a chain cable sample fails, a further sample shall be cut from the same length of cable and subjected to the test. If this re-test fails, the length of cable shall be rejected. When this test is also representative of other lengths, each of the remaining lengths shall be individually tested. If one of these further tests fails, all lengths represented by the original test shall be rejected.

5.5.10 If an accessory fails, two more accessories from the same test unit shall be selected and subjected to the test. If either of these further tests fails, the test unit shall be rejected.

### Table 7 Proof and breaking loads for short link chain cables

<table>
<thead>
<tr>
<th>Chain cable diameter mm</th>
<th>Proof load kN</th>
<th>Breaking load kN</th>
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5.6 Mechanical testing

5.6.1 Samples of chain cables and accessories shall be tensile and, where applicable, impact tested in the condition of supply, as given in Table 8, and shall meet the mechanical properties specified in Table 9. Testing of VL K1 chain cables and welded VL K2 chain cables supplied in normalised condition is not required. End links and enlarged links need not be tested provided that they are made as part of the chain and heat treated with it.

5.6.2 For chain cables, one sample link shall be taken from every four lengths of 27.5 m or less. Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that:

— each sample is properly identified with the chain represented, and
— each sample is securely attached to and heat treated with the chain represented, and
— each sample is subjected to the appropriate proof load test prior to preparation of the mechanical test pieces.

5.6.3 For accessories, one sample item or separately made representative sample shall be taken from every test unit (batch). A test unit shall consist of items of the same grade, size, heat treatment charge and a single heat of steel. The test unit need not necessarily be representative of each accessory type or individual purchase order. Separately made samples shall be in accordance with the applicable requirements given in Pt.2 Ch.2 Sec.6 or Pt.2 Ch.2 Sec.8.

5.6.4 One tensile test piece and, where applicable, one or two sets of three Charpy V-notch test pieces shall be taken from each sample at a depth one third radius below the surface. Test pieces for chain cable base materials shall be taken from the side of the link opposite the weld. For Charpy V-notch test pieces, the notch shall be cut in a face of the test piece which was originally approximately perpendicular to the surface, see Figure 7. In the case of welds, the notch shall be positioned at the centre of the weld.

5.6.5 The preparation of test pieces and the procedures used for testing shall comply with the applicable requirements in Pt.2 Ch.1.

5.6.6 If the results do not meet the specified requirements, the re-test procedures in Pt.2 Ch.1 Sec.2 may be adopted.
**Table 8 Scope of mechanical tests for chain cables and accessories**

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<th>Grade</th>
<th>Method of manufacture</th>
<th>Condition of supply</th>
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<td>Charpy V-notch impact test</td>
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**Table 9 Mechanical properties for chain cables and accessories**

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<th>Reduction of area % minimum</th>
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5.7 Inspection and dimensional tolerances

5.7.1 Surface inspection and verification of dimensions are the responsibility of the manufacturer. Acceptance by the surveyor of material later found to be defective shall not absolve the manufacturer from this responsibility.

5.7.2 All links and accessories shall be visually inspected after proof load testing and shall be free from injurious imperfections. Studs in chain cables shall be securely fastened. Minor imperfections remote from the crown may be ground off to a depth of 5% of the nominal diameter. Defective links shall be removed and replaced by connecting links of an approved type. The chain shall then be subjected to a proof load test and re-inspected. Defective accessories shall be rejected. The Society may require additional testing by NDT.

5.7.3 The entire chain cable shall be checked for length, five links at a time with an overlap of two links. The length over five links shall be minimum 22 times the nominal diameter and the maximum allowable tolerance is plus 2.5%. The measurements shall be made while the chain is loaded to about 10% of the proof load. The links held in the end blocks may be excluded from these measurements.

5.7.4 Three links selected from every four lengths of 27.5 m shall be checked for diameter, outside length, outside width and stud position. If one link fails to comply with the required tolerances in [5.7.5] and [5.7.6], measurements shall be made on a further five links in every four lengths of 27.5 m. If more than one link in a 27.5 m length fails, all the links in that length shall be measured.

5.7.5 The tolerances on chain link dimensions, except for diameter, are plus and minus 2.5%. The maximum allowable tolerance on nominal diameter measured at the crown is plus 5%. The minus tolerances on the diameter in the plane of the link at the crown are permitted to the following extent provided that the cross-sectional area at that point is at least the theoretical area of the nominal diameter:

- minus 1 mm when \( d_c \leq 40 \) mm
- minus 2 mm when \( 40 < d_c \leq 84 \) mm
5.7.6 Studs shall be located in the links centrally and at right angles to the sides of the link. The maximum off-centre distance shall be 10% of the nominal diameter and the maximum deviation from the 90° position shall be 4°.

5.7.7 Chain links failing to comply with dimensional tolerances shall be removed and replaced by connecting links of an approved type. The chain shall then be subjected to a proof load test and re-inspected.

5.7.8 One accessory selected from every test unit shall be checked for diameter and other dimensions as given in ISO 1704 or as approved. The maximum allowable tolerance on nominal diameter is plus 5% and no negative tolerance is permitted. The tolerances on other dimensions are plus and minus 2.5%. If the accessory fails to comply with the required tolerances, two more accessories from the same test unit shall be selected and measured. If either of these further accessories fails, all the accessories in the test unit shall be measured. Accessories failing to comply with dimensional tolerances shall be rejected.

5.8 Identification

5.8.1 All lengths of chain cables and all accessories shall be stamped or otherwise suitably marked with the following identification marks:
— grade of chain
— number of certificate
— the Society’s stamp.

5.8.2 Chain cables shall be marked at both ends of each length and as indicated in Figure 8.

5.8.3 Accessories that have been breaking load tested and are used as part of an outfit, as permitted in [5.5.6], shall be marked with the grade of chain for which they are intended.

Figure 8 Marking of chain cables
6 Windlass and chain stoppers

6.1 General design

6.1.1 The anchors shall normally be operated by a specially designed windlass or anchor winch. For ships with length $L < 50 \, m$, one of the cargo winches may be accepted as windlass, provided the requirements for the arrangement and function are satisfied.

6.1.2 The windlass shall have one cable lifter for each anchor stowed in hawse pipe. The cable lifter shall normally be connected to the driving shaft by release coupling and provided with brake. The number of pockets in the cable lifter shall not be less than five (5). The pockets, including the groove width etc. shall be designed for the joining shackles/kenter shackles with due attention to dimensional tolerances. When the chain cable diameter is less than 26 mm, only one of the cable lifters need be fitted with release coupling and brake.

6.1.3 For each chain cable there shall normally be a chain stopper, arranged between windlass and hawse pipe. The chain cables shall reach the hawse pipes through the cable lifter only.

6.2 Materials

6.2.1 Cable lifter shafts, cable lifters with couplings and chain pulleys shall be made from materials as stated in Table 10.

Table 10 Material requirements*)

<table>
<thead>
<tr>
<th></th>
<th>Chain cable diameter ≤ 46 mm</th>
<th>Chain cable diameter &gt; 46 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable lifters and couplings</td>
<td>Nodular cast iron or cast steel</td>
<td>Cast steel</td>
</tr>
<tr>
<td>Cable lifter shaft</td>
<td>Forged or rolled steel, cast steel</td>
<td></td>
</tr>
</tbody>
</table>

*) Other materials may be accepted subject to special consideration.

6.2.2 Windlass and chain stoppers may be cast components or fabricated from plate materials. The material in cast components shall be cast steel or nodular cast iron with elongation not less than 14%. Plate material shall be of grade as given in Table 11.

Table 11 Plate material grades

<table>
<thead>
<tr>
<th>Thickness in mm</th>
<th>Normal strength structural steel</th>
<th>High strength structural steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t \leq 20$</td>
<td>A</td>
<td>AH</td>
</tr>
<tr>
<td>$20 &lt; t \leq 25$</td>
<td>B</td>
<td>AH</td>
</tr>
<tr>
<td>$25 &lt; t \leq 40$</td>
<td>D</td>
<td>DH</td>
</tr>
<tr>
<td>$40 &lt; t \leq 150$</td>
<td>E</td>
<td>EH</td>
</tr>
</tbody>
</table>

*) For plates above 40 mm joined with fillet-/partly penetration welds, grade D and DH will normally be accepted.
6.2.3 Weld joint designs shall be shown in the construction plans and shall be approved in association with the approval of the windlass design. Welding procedures and welders shall be qualified in accordance with the requirements of DNV GL. Welding consumables shall be type approved by DNV GL.

6.3 Mechanical design

6.3.1 The windlass with prime mover shall be able to exert the pull specified by Table 12 directly on the cable lifter. Under these load conditions, stresses in each torque-transmitting component shall not exceed 40% of yield strength of the material. For double windlasses, the requirements apply to one side at a time. Manual operation as the main driving power may be allowed for anchors weighing up to 250 kg. Manually operated windlasses shall, as a minimum, be capable of hoisting at mean speed of 2 m/min with the lifting force specified in Table 12. This shall be achieved without exceeding a manual force of 150 N applied to a crank radius of maximum 350 mm with the hand crank turned at maximum 30 rpm.

Table 12 Lifting power

<table>
<thead>
<tr>
<th>Lifting force and speed</th>
<th>Grade of chain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K1</td>
</tr>
<tr>
<td>Normal lifting force for 30 min, in N</td>
<td>$37.5 \cdot d_c^2$</td>
</tr>
<tr>
<td>Mean hoisting speed</td>
<td>9 m/min.</td>
</tr>
<tr>
<td>Maximum lifting force for 2 minutes (no speed requirement)</td>
<td>$1.5 \cdot$ normal lifting force</td>
</tr>
</tbody>
</table>

The values of Table 12 are applicable when using ordinary stockless anchors for anchorage depth down to 82.5 m. For anchorage depth deeper than 82.5 m, the normal lifting force according to Table 12 shall be increased by $(D - 82.5) \times 0.27d_c^2$ in N, where D is the anchor depth in metres.

Guidance note:
The anchor masses are assumed to be the masses as given in Table 2. Also, the value of normal lifting force is based on the hoisting of one anchor at a time, and that the effects of buoyancy and hawse pipe efficiency (assumed to be 70%) have been accounted for.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.2 Attention shall be paid to stress concentrations in keyways and other stress raisers and also to dynamic effects due to sudden starting or stopping of the prime mover or anchor chain. The design of the drive train, including prime mover, reduction gears, bearings, clutches, shafts, cable lifter and bolting shall consider the dynamic effects of sudden stopping and starting of the prime mover or chain cable so as to limit inertial load.

6.3.3 For the protection of the mechanical parts in the event of the windlass jamming, an overload protection (e.g. slip coupling, relief valve) shall be fitted to limit the maximum torque of the drive engine (maximum torque resulting from maximum lifting force based on Table 12). The setting of the overload protection shall be specified (e.g. in the operating instructions).

To protect mechanical parts, including component housings, a suitable protection system shall be fitted to limit the speed and torque at the prime mover. Consideration shall be given to a means to contain debris resulting from a severe damage of the prime mover due to over-speed in the event of uncontrolled rendering of the cable, particularly when an axial piston type hydraulic motor is the prime mover.

6.3.4 The capacity of the windlass brake shall be sufficient for safe stopping of anchor and chain cable when paying out.
The windlass with brakes engaged and release coupling disengaged shall be able to withstand a static pull of 45% of the chain cable minimum breaking strength given in Table 6, without any permanent deformation of the stressed parts and without brake slip.

If a chain stopper is not fitted, the windlass shall be able to withstand a static pull equal to 80% of the minimum breaking strength of the chain cable, without any permanent deformation of the stressed parts and without brake slip.

In addition, where the gear mechanism is not of a self-locking type, a device (e.g. gearing brake, lowering brake, oil hydraulic brake) shall be fitted to prevent paying out of the chain in case of power unit failure while the cable lifter is engaged.

If brakes are power operated, additional means shall be provided for manual operation. Manual operation shall be possible under all working conditions, including failure of the power drive. During the static pull, the force exerted on the brake handwheel shall not exceed 500 N.

6.3.5 Windlasses shall be fitted with couplings which are capable of disengaging between the cable lifter and the drive shaft. Hydraulically or electrically operated couplings shall be capable of being disengaged manually. Manual operation shall be possible under all working conditions, including failure of the power drive. In the case of windlasses with two cable lifters both cable lifters shall be engageable simultaneously.

6.3.6 The chain stoppers and their attachments shall be able to withstand 80% of the minimum breaking strength of the chain cable, without any permanent deformation of the stressed parts. The chain stoppers shall be so designed that additional bending of the individual link does not occur and the links are evenly supported. Bar type chain stoppers having contact with the chain link from one side may be accepted after special consideration and provided that satisfactory strength is demonstrated by calculation or prototype test.

6.4 Hydraulic systems

Hydraulic systems intended for driving windlasses shall comply with the requirements in Pt.4 Ch.6 Sec.5 [8]. Documentation shall be submitted according to Pt.4 Ch.6 Sec.1 Table 2 for Anchor windlasses hydraulic system. Hydraulic pumps shall be certified as required by Pt.4 Ch.6 Sec.1 Table 4.

Guidance note:
In the case of hydraulic drives with a piping system connected to other hydraulic systems a second pump unit is recommended.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.5 Electrical

Anchor windlasses are considered as important consumers. Electrical systems and components shall comply with the requirements for important consumers in Pt.4 Ch.8. Documentation for the motor starter shall be submitted according to Pt.4 Ch.8 Sec.1 Table 2 for Electrical assemblies. Electrical motors and motor starters shall be certified as required by Pt.4 Ch.8 Sec.1 [2.3].

6.6 Testing

6.6.1 Before assembly the following parts shall be pressure tested:
— housings with covers for hydraulic motors and pumps
— hydraulic pipes
— valves and fittings
— pressure vessels
— steam cylinders.

The tests shall be carried out in accordance with Pt.4 Ch.6 Sec.5 and Pt.4 Ch.6 Sec.7, and Pt.4 Ch.7. Test pressure for steam cylinders shall be 1.5 times the working steam pressure.
6.6.2 After completion, at least one prime mover of the windlass shall be shop tested with respect to required lifting forces and, if relevant, braking forces. Calculations indicating compliance with the requirements given in [6.3.1] and [6.3.4] may be dispensed with when complete shop test verification shall be carried out. In such case, a test program shall be submitted on request.

Acceptance tests shall include the following tests, as a minimum:

— **No-load test.** The windlass shall be run without load at nominal speed in each direction for a total of 30 minutes. If the windlass is provided with a gear change, additional run in each direction for 5 minutes at each gear change is required

— **Load test.** The windlass shall be tested to verify that the continuous duty pull, overload capacity and hoisting speed as specified in Table 12 can be attained. Where the manufacturing works does not have adequate facilities, these tests, including the adjustment of the overload protection, can be carried out on board ship. In these cases, functional testing in the manufacturer’s works shall be performed under no-load conditions

— The holding power of the brake shall be verified either through testing or by calculation.

6.6.3 After installation of the windlass on board, an anchoring test shall be carried out to demonstrate that each windlass with brakes and chain stopper, if fitted, etc. functions satisfactorily.

Each windlass shall be independently tested for proper riding of the chain over the cable lifter, proper transit of the chain through the hawse pipe and the chain pipe, and effecting proper stowage of the chain and the anchor. It shall be confirmed that anchors properly seat in the stored position and that chain stoppers function as designed, if fitted. The braking capacity shall be tested by intermittently paying out and holding the chain cable by means of the application of the brake.

The mean speed on the chain cable when hoisting the anchor and cable shall not be less than 9 m/min and shall be measured over two shots (55 m) of chain cable during the trial. The trial shall be commenced with three (3) shots (82.5 m) of chain cable fully submerged and the anchor hanging free. Where the depth of water in trial areas is inadequate, consideration will be given to acceptance of equivalent simulated conditions.

6.7 Marking

Each windlass shall be permanently marked with at least the following information:

— nominal size of chain (chain diameter, grade and breaking load)
— maximum anchorage depth, in metres.
SECTION 2 SUPPORTING STRUCTURE FOR DECK EQUIPMENT AND FITTINGS

Symbols
For symbols not defined in this section, see Ch.1 Sec.4.

1 General

1.1 Application

1.1.1 Information pertaining to the supporting structure for deck equipment and fittings, as listed in this section, shall be submitted for approval.

This section includes scantling requirements for the supporting structure and foundations of the following pieces of equipment and fittings:

a) anchor windlasses
b) anchoring chain stoppers
c) mooring winches
d) deck cranes, derricks and lifting masts
e) bollards and bitts, fairleads, stand rollers, chocks and capstans.

1.1.2 Where deck equipment is subjected to multiple load cases, such as operational loads and green sea load, the loads shall be applied independently for the evaluation of strength of foundations and support structure.

1.2 Documents to be submitted

The documents to be submitted are indicated in Ch.1 Sec.3.

2 Anchoring windlass and chain stopper

2.1 Application

This article applies to foundations and supporting structure for windlass and chain stoppers required to be installed in accordance with Sec.1 Table 2.

2.2 General

2.2.1 The hull supporting structure of anchor windlass and chain stopper shall be sufficient to accommodate the operating and sea loads.

2.2.2 The windlass and chain stoppers shall be efficiently bedded to the deck. The deck plating in way of windlass and chain stopper shall be increased in thickness and supported by strengthened deck structure comprised by pillars and girders carried down to rigid structures.

2.2.3 The builder and the windlass manufacturer shall ensure that the foundation is suitable for the safe operation and maintenance of the windlass equipment.
2.3 Design loads for anchoring operation

2.3.1 The following load cases shall be examined for the anchoring operation, as appropriate:

a) Windlass where chain stopper is provided: 45% of BS.
b) Windlass where chain stopper is not provided: 80% of BS.
c) Chain stopper: 80% of BS.

where:

BS = minimum breaking strength of the chain cable in kN.

2.3.2 Where a separate foundation is provided for the windlass brake, the distribution of resultant forces shall be calculated on the assumption that the brake is applied for load cases (a) and (b) defined in [2.3.1].

2.4 Design loads for fore deck windlass against green sea

2.4.1 The requirements given in this subsection apply to windlass at its supporting structure, when located on an exposed deck over the forward 0.25 \( L \) of the ship. The application is limited to ships of length 80 m or more, where height of the exposed deck where windlass is fitted is less than 0.1 \( L \) or 22 m above the summer load waterline, whichever is the lesser.

2.4.2 Where mooring winches are integral with the anchor windlass, they shall be considered as part of the windlass.

2.4.3 The following forces shall be applied in the independent load cases that shall be examined for the design loads due to green sea, see Figure 1:

\[ P_x = 200 A_x, \text{ in kN, acting normal to the shaft axis.} \]
\[ P_y = 150 A_y f, \text{ in kN, acting parallel to the shaft axis (inboard and outboard directions to be examined separately).} \]

where:

\[ A_x = \text{projected frontal area, in m}^2 \]
\[ A_y = \text{projected side area, in m}^2 \]
\[ f = 1 + B_w/H, \text{ but not to be taken greater than 2.5} \]
\[ B_W = \text{breadth of windlass measured parallel to the shaft axis, in m, see Figure 1} \]
\[ H = \text{overall height of windlass, in m, see Figure 1}. \]
2.4.4 Forces resulting from green sea design loads in the bolts, chocks and stoppers securing the windlass to the deck shall be calculated. The windlass is supported by a number of bolt groups, \( N \), each containing one or more bolts. See Figure 2.

**Figure 1 Directions of forces and weight**

**Figure 2 Bolting arrangements and sign conventions**
2.4.5 The axial forces, $R_{xi}$ and $R_{yi}$, in kN, in bolt group (or bolt) $i$, positive in tension, are given by:

$$R_{xi} = P_x h x_i A_i / I_x$$

$$R_{yi} = P_y h y_i A_i / I_y$$

$$R_i = R_{xi} + R_{yi} - R_{si}$$

where:

$P_x$ = force acting normal to the shaft axis, in kN

$P_y$ = force acting parallel to the shaft axis, either inboard or outboard, whichever gives the greater force in bolt group $i$, in kN

$h$ = shaft centre height above the windlass mounting, in cm, see Figure 1

$x_i, y_i$ = $x$ and $y$ coordinates of bolt group $i$ from the centroid of all $N$ bolt groups, in cm. Positive in the direction opposite to that of the applied force

$A_i$ = cross sectional area of all bolts in group $i$, in cm$^2$

$I_x = \Sigma A_i x_i^2$ for $N$ bolt groups, in cm$^4$

$I_y = \Sigma A_i y_i^2$ for $N$ bolt groups, in cm$^4$

$R_{si}$ = static reaction at bolt group $i$, due to the weight of windlass, in kN.

2.4.6 The shear forces, $F_{xi}$ and $F_{yi}$, in kN, applied to the bolt group $i$, and the resultant combined force $F_i$, are given by:

$$F_{xi} = (P_x - C_1 gm) / N$$

$$F_{yi} = (P_y - C_1 gm) / N$$

$$F_i = \sqrt{F_{xi}^2 + F_{yi}^2}$$

where:

$C_1$ = coefficient of friction, taken equal to 0.5

$m$ = mass of windlass, in t

$g$ = acceleration due to gravity, 9.81 m/s$^2$

$N$ = number of bolt groups.

2.4.7 The tensile axial stresses resulting from green sea design loads in the individual bolts in each bolt group $i$ shall not exceed 50% of the bolt proof strength. The load shall be applied in the direction of the chain cable. Where fitted bolts are designed to support shear forces in one or both directions, the von Mises equivalent stresses shall not exceed 50% of the bolt proof strength.

When chocks are made of pourable resins, steel stoppers shall be arranged.

2.4.8 The horizontal forces resulting from the green sea design loads, $F_{xi}$ and $F_{yi}$, may be supported by shear chocks. Where pourable resins are incorporated in the holding down arrangements, due account shall be taken in the calculation.
2.5 Acceptance criteria

2.5.1 Strength assessment shall be based on gross scantling.

2.5.2 The stress resulting from design loads based on [2.3] and [2.4], induced in the supporting structure, shall not be greater than the following permissible values:

\[
\text{Normal stresses} = R_{eH} \\
\text{Shear stresses} = \tau_{eH}
\]

3 Heavy equipment, winches others than those used for mooring and towing and other pulling accessories

3.1 Application

3.1.1 This subsection applies to supporting structures for heavy equipment and deck machinery in general. Foundations and structures covered by [2], [4] and [5] need not comply with this subsection.

— Heavy equipment: equipment where the static forces exceed 50 kN or resulting static bending moments at deck exceed 100 kNm.

— Deck machinery: winches not used for mooring and towing, windlasses, chain stoppers, and other similar items, including stern rollers and shark jaws for handling chains of offshore rigs fitted on board offshore support vessels, with breaking load of the wire or chain > 150 kN, or \( SWL > 30 \) kN.

3.1.2 For supporting structure of temporary mounted equipment on deck, see the Society’s document DNVGL-CG-0156 Conversions.

3.2 Materials

3.2.1 Selection of material grades for plates and sections shall be based on material thickness. Steel grade given in Table 1 or equivalent is acceptable.

3.2.2 Deck doublers are generally not accepted if tension perpendicular to deck occurs.

**Table 1 Plate material grades**

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Normal strength structural steel</th>
<th>High strength structural steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t \leq 40 )</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>( 40 &lt; t \leq 150 )</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>
3.3 Design loads

3.3.1 Heavy equipment
Load application for supporting structure for heavy equipment is given in Ch.6 Sec.2. Envelope accelerations as defined in Ch.4 Sec.3 [3.3] may be applied.

3.3.2 Winches and other pulling accessories
The strength of the supporting structures shall fulfil the strictest of the following design loads as found relevant:
   a) Design load to be given by the respective SWL times dynamic coefficient, $\psi$, as specified by designer. $\psi$ shall however not be taken less than 1.3.
   b) Design load to be given by the force in the rope causing the brake to render.
   c) For winches with constant tension control, design load to be taken as 1.1 times the maximum pulling force.
   d) For transit condition, see Ch.6 Sec.2.
   e) For winches, e.g. trawl winches, where the rope/equipment can get stuck on the sea bottom or otherwise, the design load shall be equal to the breaking load of the rope.

3.4 Acceptance criteria

3.4.1 Strength assessment shall be based on gross scantling.

3.4.2 The stresses resulting from design loads specified in [3.3.1] shall not be greater than the permissible stress as given in Ch.6 accordingly.

3.4.3 The stresses resulting from design loads a) to d) as specified in [3.3.2] shall not be greater than the following permissible values:
   \begin{align*}
   \text{Normal stresses} & = 0.67 R_y \\
   \text{Shear stresses} & = 0.67 \tau_y
   \end{align*}

3.4.4 The stresses resulting from design load e) specified in [3.3.2] shall not be greater than the following permissible values:
   \begin{align*}
   \text{Normal stresses} & = 0.9 R_y \\
   \text{Shear stresses} & = 0.9 \tau_y
   \end{align*}

4 Cranes, A-frames, derricks, lifting masts and life saving appliances

4.1 Application and definition

4.1.1 The supporting structures for cranes, derricks and other lifting appliances with safe working load greater than 30 kN and/ or the maximum overturning moment greater than 100 kNm, shall comply with these requirements. The strength of supporting structure of lifting appliances with lower working load/ overturning moment shall be confirmed with load test according to applicable standards.
Guidance note:
If the pedestal and supporting structure of crane is designed in compliance with DNVGL-ST-0377 and DNVGL-ST-0378 then this is regarded as also complying with the requirements below.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.2 Supporting structures of appliances for launching and recovery of lifesaving appliances and work boats shall comply with these requirements regardless of safe working load and overturning moment.

4.1.3 These requirements apply to the connection to the deck and the supporting structure of cranes, A-frames, derricks and lifting masts.

4.1.4 These requirements do not cover the following items:
- Supports of lifting appliances for personnel or passengers, except supporting structure for life saving appliances.
- Holding down bolts and their arrangement, which are considered part of the lifting appliance.

The term, lifting appliance, is defined as a crane, A-frame, derrick or lifting mast.

4.1.5 The crane including pedestal flange and bolts or the lifting gear itself is not subject to approval, unless class notation Crane, Diving support vessel or Crane vessel is requested.

Guidance note:
If ILO certification of lifting appliances is requested and the Society shall issue the certificate, approval of documentation will be required. See the Society’s documents DNVGL-ST-0377 Standard for shipboard lifting appliances and DNVGL-ST-0378 Standard for offshore and platform lifting appliances.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.6 Self weight
The self weight is the calculated gross self weight of the lifting appliance, including the weight of any lifting gear.

4.1.7 Working load (W)
Working load (W) is safe working load (SWL) plus the weight of the lifting gear, e.g. hook block. See also the Society’s documents DNVGL-ST-0377 Standard for shipboard lifting appliances and DNVGL-ST-0378 Standard for offshore and platform lifting appliances.

4.1.8 Overturning moment
The overturning moment is the maximum bending moment, calculated at the connection of the lifting appliance to the ship structure, due to the lifting appliance operating at safe working load, taking into account outreach and self weight. Increase of outreach due to vessel’s heel and trim angle should be considered when calculating the overturning moment.

Guidance note:
See DNVGL-ST-0377 and DNVGL-ST-0378 for more detailed description of self weight, working load and overturning moment for crane and crane foundation.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.9 The crane pedestal and derrick mast are as defined in Figure 3.
4.2 General

4.2.1 Design of foundations and supporting structure for lifting appliances in general, e.g. cranes and A-frames, intended for large loads, having a complex arrangement and or comprised by irregular shaped plating, shall be supported by a direct strength analysis at an extent and content to be agreed before hand with the Society. FE calculations shall follow principles outlined in Ch.7 Sec.3 and/or Ch.7 Sec.4.

4.3 Materials

4.3.1 For pedestal/posts and supporting structures, selection of material grade for plates and sections shall be based on Table 2.
### Table 2 Plate material grades

<table>
<thead>
<tr>
<th>Thickness in mm</th>
<th>Normal strength structural steel</th>
<th>High strength structural steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t \leq 20$</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>$20 &lt; t \leq 25$</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>$25 &lt; t \leq 40$</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>$40 &lt; t \leq 150$</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

#### 4.3.2 For offshore cranes, as defined in Ch.1 Sec.4 Table 7, the selection of materials for crane pedestal and respective foundation shall be based on the Society’s document DNVGL-ST-0378 Standard for offshore and platform lifting appliances.

If not otherwise stated the design temperature $T_D$, for determination of the impact test temperature, shall be $-20°C$ or lower.

#### 4.3.3 When a pedestal subjected to bending is not continuous through a deck plating, the following applies:

a) Z-quality material, see Pt.2 Ch.2 Sec.2 [6], shall be used, or

b) The material may be accepted based on a case-by-case evaluation of the chemical composition, with special attention to the sulphur content which shall satisfy the requirements for Z-quality steels. In addition an ultrasonic test of the plate before welding shall be carried out in the tension exposed areas according to the requirements to Z-quality steels, see Pt.2 Ch.2 Sec.2 [6].

#### 4.4 Structural arrangement

#### 4.4.1 Deck plating and under deck structure shall provide adequate support for derrick masts and crane pedestals against the loads and maximum overturning moment. Where the deck is penetrated, the deck plating shall be suitably strengthened.

#### 4.4.2 Structural continuity of the deck structure shall be maintained.

Under deck members shall be provided to support the crane pedestal and to comply with:

a) Where the pedestal is directly connected to the deck, without above deck brackets, adequate under deck structure directly in line with the crane pedestal shall be provided. Where the crane pedestal is attached to the deck without bracketing or where the crane pedestal is not continuous through the deck, welding to the deck of the crane pedestal and its under deck support structure shall be made by suitable full penetration welding. The design of the weld connection shall be adequate for the calculated stress in the welded connection, in accordance with [4.6.2].

b) Where the pedestal is directly connected to the deck with brackets, under deck support structure shall be fitted to ensure a satisfactory transmission of the load, and to avoid structural hard spots. Above deck brackets may be fitted inside or outside of the pedestal and shall be aligned with deck girders and webs. The design shall avoid stress concentrations caused by an abrupt change of section. Brackets and other direct load carrying structure and under deck support structure shall be welded to the deck by suitable full penetration welding. The design of the connection shall be adequate for the calculated stress, in accordance with [4.6.2].

c) Support of heavily loaded crane pedestals shall preferably be provided by at least 2 deck levels. The supporting structure shall have continuity and allow safe access for survey of its interior. Reference is made to Figure 4 and Figure 5.
4.4.3 Deck plating shall be of a material strength compatible with the crane pedestal. Where necessary, a thicker insert plate shall be fitted. In no case shall doublers be used where structures are subjected to tension.

4.5 Design loads

4.5.1 The structural strength of the supporting structure (including pedestal) shall be based on a design load consisting of the working load ($W$) multiplied by the dynamic factor $\psi$ (specified by the crane designer) plus the self-weight. However, the dynamic factor shall normally not be taken less than the following:

For cranes when operation in harbour:
- $\psi = 1.3$, a lower factor may be applied based on design value for the crane design accepted by the Society.

For cranes when operated offshore:
- $\psi = 1.3$ for $10 \text{ kN} < W \leq 2500 \text{ kN}$
- $\psi = 1.1$ for $W > 5000 \text{ kN}$.
Linear interpolation shall be used for values of $W$ between 2500 kN and 5000 kN.

For offshore cranes the design loads for the supporting structure shall be taken as the design loads for the crane multiplied with an additional offshore safety factor $SF1$ of 1.1.

For offshore cranes with $W \leq 2500$ kN, where the operator cabin is attached above the slewing bearing, $SF1$ shall be taken as 1.3.

Lifting appliances fitted with shock absorbers may be specially considered.

4.5.2 For life saving appliances, e.g. davit and winch supporting structures for life boat, life raft and man-overboard boat, design load shall be taken as 2.2 times SWL.

4.5.3 For man-overboard boat davits, the supporting structure shall also be designed to withstand a horizontal towing force.

4.5.4 For non-compact units wind and icing shall be taken into account as appropriate.

4.5.5 Standard ice load for North Sea winter conditions may be taken as 5 cm ice deposit on wind and weather exposed surfaces.

4.6 Acceptance criteria

4.6.1 Strength assessment shall be based on gross scantlings.

4.6.2 The acceptance criteria in this paragraph and [4.6.3] apply for design loads from crane in operation. Similar acceptance criteria for strength check of stored crane in transit will be as for AC-II, see Ch.7 Sec.3 [4].

The stresses obtained by beam assessment of the supporting structure shall not exceed the following permissible values:

Normal stress \[ = 0.67 \ R_y \]

Shear stress \[ = 0.67 \ \tau_y \]

The capability of the supporting structure to resist buckling failure in harbour and seagoing conditions shall be assured applying maximum permissible utilization factor:

\[ \eta_{all} = 0.67 \]

For strength assessment based on finite element analysis the following acceptance criteria apply:

a) For area $s \times s$

\[ \sigma_{vm} \leq 0.67 R_y \]

b) For fine mesh 50 × 50 mm, acceptance criteria is:

\[ \sigma_{vm} \leq R_y \]

This criteria shall be applied in addition to the criteria for $s \times s$ mesh in a).

4.6.3 For knuckles or other details where high surface stresses are expected, an analysis of hot-spot stresses covering both low cycle and high cycle fatigue may be required, see the Society’s document DNVGL-CG-0129 Fatigue assessment of ship structures. Such analysis may be applied in lieu of the yield criteria for 50 x 50 mm mesh criteria in [4.6.2] b), but the criteria in [4.6.2] a) shall apply.
4.6.4 Fatigue calculations shall be submitted upon request for designs with high utilization at transition to ships deck, at knuckles and/or other details. The calculations shall be based on a recognized method (e.g. DNVGL-CG-0129) and take into account relevant loads from crane and vessel in operation and in transit.

5 Shipboard fittings and supporting hull structures associated with towing and mooring

5.1 Application and definitions

5.1.1 Conventional ships shall be provided with arrangements, equipment and fittings of sufficient safe working load to enable the safe conduct of all towing and mooring operations associated with the normal operations of the ship.

Conventional ships means displacement-type ships of 500 GT and above, excluding high speed craft and offshore units of all types.

5.1.2 This subsection applies to design and construction of shipboard fittings and supporting structures used for the normal towing and mooring operations. Normal towing means towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operations of the ship.

5.1.3 For ships, not subject to SOLAS Regulation II-1/3-4 Paragraph 1, but intended to be fitted with equipment for towing by another ship or a tug, e.g. such as to assist the ship in case of emergency as given in SOLAS Regulation II-1/3-4 Paragraph 2, the requirements designated as ‘other towing’ in this subsection shall be applied to design and construction of those shipboard fittings and supporting hull structures.

5.1.4 This subsection is not applicable to design and construction of shipboard fittings and supporting hull structures used for special towing services defined as:

- **Canal transit towing**: Towing service for ships transiting canals, e.g. the Panama Canal. It shall be referred to local canal transit requirements.
- **Emergency towing for tankers**: Towing service to assist tankers in case of emergency. For the emergency towing arrangements, ships subject to SOLAS regulation II-1/3-4 Paragraph 1 shall comply with that regulation and resolution MSC.35 (63) as may be amended.
- **Escort towing**: Towing service, in particular, for laden oil tankers or LNG carriers, required in specific estuaries. It shall be referred to local escort requirements and guidance given by, e.g., the Oil Companies International Marine Forum (OCIMF).

5.1.5 Shipboard fitting means those components limited to the following: bollards and bitts, fairleads, stand rollers, chocks used for normal mooring of the vessel and the similar components used for normal or other towing of the vessel. Other components such as capstans and winches are not covered by these rules. Any weld or bolt or equivalent device connecting the shipboard fitting to the supporting structure is part of the shipboard fitting and if selected from an industry standard subject to that standard.

5.1.6 Supporting hull structures means that part of the ship structure on/in which the shipboard fitting is placed and which is directly subjected to the forces exerted on the shipboard fitting. The supporting structure of capstans and winches used for normal or other towing and mooring operations mentioned above is also subject to these requirements.

5.1.7 Equipment and supporting structures covered by separate class notations like e.g. Tug, Tug(Escort X(F_{g},t,v)) or Offshore service vessel are not covered by the below requirements, but shall comply with the requirements in the respective sections, e.g. Pt.5 Ch.9 Sec.2 or Pt.5 Ch.10 Sec.11.

5.1.8 The net minimum scantlings of the supporting hull structure shall comply with the requirements given in [5.4]. 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 corrosion addition, \( t_c \), given in [5.8.1], to \( t_{net} \). Shipboard fittings shall comply with the requirements given in [5.3]. For shipboard fittings not selected from an accepted industry standard the corrosion addition, \( t_c \), and the wear allowance, \( t_w \), given in [5.8.1] and [5.8.2], respectively, shall be considered.

**Guidance note:**

Industry standard means international standards (ISO, etc.) or standards issued by national association such as DIN or JMSA, etc. which are recognized in the country where the ship is built.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

### 5.2 Material

The material in deck fittings and supporting structure shall be at least grade A or equivalent. Casting in mooring and towing equipment shall be of weldable quality.

### 5.3 Shipboard fittings

#### 5.3.1 The selection of shipboard fittings may be made by the shipyard in accordance with an Industry standard, e.g. ISO13795 *Ships and marine technology - Ship's mooring and towing fittings - Welded steel bollards for sea-going vessels*, accepted by the Society and at least based on the following loads:

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

b) For other towing service, the minimum breaking strength of the tow line according to Sec.1 Table 1.

c) For fittings intended to be used for, both, normal and other towing operations, the greater of the loads according to a) and b).

d) For mooring operations, the minimum breaking strength of the mooring line according to Sec.1 [3.2] or Sec.1 [3.3], as applicable.

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.

Mooring bitts (double bollards) shall 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.

**Guidance 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.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

#### 5.3.2 When a shipboard fitting is not selected from an accepted Industry standard, the design is subject to approval. The design load used to assess its strength and its attachment to the ship shall be in accordance the relevant requirements given in [5.4], [5.5] and [5.6]. Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice. Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion.

For strength assessment beam theory or finite element analysis using net scantlings shall be applied, as appropriate. Corrosion additions shall be as defined in [5.8.1]. A wear down allowance shall be included as defined in [5.8.2]. At the discretion of the Society, load tests may be accepted as alternative to strength assessment by calculations.
5.4 Supporting hull structures

5.4.1 Shipboard fittings for towing and mooring, winches and capstans for mooring shall be located on stiffeners and/or girders, which are part of the deck structure, so as to facilitate efficient distribution of the load. Other arrangements may be accepted (for chocks in bulwarks, etc.) provided the strength is confirmed adequate for the intended service.

5.4.2 The design load applied to supporting hull structure shall be in accordance with [5.5].

5.4.3 The deck strengthening beneath shipboard fittings, winches and capstans shall be effectively arranged for any variation of direction (horizontally and vertically) of the design loads acting upon the shipboard fittings, see Figure 6 for a sample arrangement. Proper alignment of fitting and supporting hull structure shall be ensured.

![Figure 6 Sample arrangement](image_url)

Figure 6 Sample arrangement

5.4.4 The acting point of the towing/mooring forces on deck fittings shall be taken at the attachment point of a towing/mooring line or at a change in its direction. For bollards and bitts the attachment point of the towing/mooring line shall be taken not less than 4/5 of the tube height above the base, see Figure 7 and a) in Figure 8 for towing and mooring respectively. However, 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 Figure 8.

![Figure 7 Attachment point of the towing line](image_url)
Figure 8 Attachment point of the mooring line

5.4.5 The structural arrangement shall provide continuity of strength.

The structural arrangement of the ship’s structure in way of the shipboard fittings and their seats and in way of capstans shall be such that abrupt changes of shape or section shall be avoided in order to minimise stress concentrations. Sharp corners and notches shall be avoided, especially in highly stressed areas.

5.4.6 The supporting structure shall be dimensioned to ensure that for the loads specified in [5.5.1] to [5.5.4], the stresses do not exceed the permissible values given in [5.6].

The capability of the structure to resist buckling failure shall be assured.

5.4.7 Strength calculations shall be based on net scantlings after deduction of corrosion addition. For this purpose, the corrosion addition, $t_c$, in mm, for the supporting structure shall be taken as given in [5.8.1].

5.5 Design loads

5.5.1 Unless greater safe working load (SWL) or safe towing load (TOW) of shipboard fittings is specified by the designer, the minimum design load to be used is the following, whichever is applicable:

a) For normal towing operations, 1.25 times the intended maximum towline load, e.g. static bollard pull, as indicated on the towing and mooring arrangement plan.

b) For other towing service, the minimum breaking strength of the towing line according to values given in Sec.1, for the ship’s corresponding equipment number.

c) For fittings intended to be used for, both, normal and other towing operations, the greater of the design loads according to a) and b).

d) For mooring operation, the design load shall be 1.15 times the minimum breaking strength of the mooring line according to values given in Sec.1, for the ship’s corresponding equipment number.

For the purpose of defining breaking strength of the towing and mooring lines, the projected area including deck cargo as given by the loading manual shall be considered in the calculations of the equipment number, see Sec.1 [3.1.2].
5.5.2 The minimum design load to be applied to supporting hull structures for mooring winches, etc. shall be 1.25 times the intended maximum brake holding load, where the maximum brake holding load shall be assumed not less than 80% of the minimum breaking strength of the mooring line according to Sec.1. For supporting hull structures of capstans, 1.25 times the maximum hauling in force shall be taken as the minimum design load.

5.5.3 The design load shall 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/mooring 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 9. 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 9 Design load on fitting](image)

5.5.4 When a safe towing load TOW or safe working load SWL greater than that determined according to [5.7] is requested by the applicant, then the design load shall be increased in accordance with the appropriate TOW/design load or SWL/design load relationship given by [5.5] and [5.7].

5.6 Acceptance criteria

5.6.1 For the design load specified in [5.5], the stresses, in N/mm$^2$, induced in the shipboard fittings, supporting structure and welds shall not exceed permissible values defined in [5.6.2] and [5.6.3], as applicable.

5.6.2 For strength assessment with beam theory or grillage analysis:

\[
\text{Normal stress} = R_{eH} \\
\text{Shear stress} = 0.6R_{eH}
\]

Normal stress is the sum of bending stress and axial stress. No stress concentration factors being taken into account.

5.6.3 For strength assessment with finite element analysis:

\[
\text{Equivalent stress} = R_{eH}
\]

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

5.7 Safe towing load (TOW) and safe working load (SWL)

5.7.1 The safe towing load (TOW) is the load limit for towing purpose. The following requirements for safe towing load (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.

a) TOW used for normal towing operations shall not exceed 80% of the design load per [5.5.1] item (a).
b) TOW used for other towing operations shall not exceed 80% of the design load according to [5.5.1] item (b).
c) For fittings used for both normal and other towing operations, the greater of the safe towing loads according to a) and b) shall be used.
d) For fittings intended to be used for, both, towing and mooring, [5.7.2] applies to mooring.
e) TOW, in t, of each shipboard fitting shall be marked (by weld bead or equivalent) on the deck fittings used for towing. For fittings intended to be used for, both, towing and mooring, SWL, in t, according to [5.7.2] shall be marked in addition to TOW.
f) The towing and mooring arrangements plan mentioned in [5.7.3] shall define the method of use of towing lines.

5.7.2 The safe working load (SWL) is the load limit for mooring purpose. The following requirements for safe working load (SWL) apply for the use with no more than one mooring line.

a) Unless a greater SWL is requested by the applicant according to [5.5.4], the SWL shall not exceed the minimum breaking strength of the mooring line according to Sec.1.
b) The SWL, in t, of each shipboard fitting shall be marked (by weld bead or equivalent) on the deck fittings used for mooring. For fittings intended to be used for, both, mooring and towing, TOW, in t, according to [5.7.1] shall be marked in addition to SWL.
c) The towing and mooring arrangements plan mentioned in [5.7.3] shall define the method of use of mooring lines.

5.7.3 The SWL and TOW for the intended use for each deck fitting shall be stated in the towing and mooring arrangements plan available onboard. It shall be noted that TOW is the load limit for towing purpose and SWL that for mooring purpose. If not otherwise chosen, for towing bitts it shall be noted that TOW is the load limit for a towing line attached with eye-splice. For each deck fitting, the following shall be included:

a) location on the ship
b) fitting type
c) SWL/TOW
d) purpose (mooring/harbour towing/other towing)
e) manner of applying towing or mooring line load including limiting fleet angles.

Item (c) with respect to items (d) and (e), is subject to approval by the Society.

Furthermore, information provided on the plan shall include:

a) the arrangement of mooring lines showing number of lines (n)
b) the minimum breaking strength of each mooring line (MBL)
c) the acceptable environmental conditions as given in Sec.1 [3.3.3] or Sec.1 [3.3.4], respectively for the recommended minimum breaking strength of mooring lines for ships with equipment number EN > 2000:
   — 30 second mean wind speed from any direction (\(v_w\) or \(v_{w*}\))
— maximum current speed acting on bow or stern (±10°).

This information shall be incorporated into the pilot card in order to provide the pilot with proper information on harbour and other towing operations.

5.8 Corrosion addition and wear allowance

5.8.1 The corrosion addition, \( t_c \), shall not be less than the following values:

— For the supporting hull structure, according to the rules for the surrounding structure (e.g. deck structures, bulwark structures).
— For pedestals and foundations on deck which are not part of a fitting according to an accepted industry standard, 2.0 mm.
— For shipboard fittings not selected from an accepted industry standard, 2.0 mm.

5.8.2 For shipboard fittings not selected from an accepted industry standard, a wear allowance, \( t_w \), not less than 1.0 mm, shall be added to surfaces which are intended to regularly contact the line.

6 Miscellaneous deck fittings

6.1 Support and attachment

6.1.1 The following requirements shall be considered in the design of the support and attachment of miscellaneous fittings which impose relatively small loads on the ship’s structure. The arrangement of such details and their approval is considered on a case-by-case basis.

6.1.2 Support positions shall be arranged so that the attachment to the ship structure is clear of deck openings and stress concentrations, such as the toes of end brackets. Design of supports shall be such that the attachment to the deck minimises the creation of hard points.

6.1.3 The other requirements related to ship types and class notations are covered as given in Pt.5 and Pt.6 respectively.
SECTION 3 BULWARK AND PROTECTION OF CREW

Symbols
For symbols not defined in this section, see Ch.1 Sec.4.

1 General requirements

1.1 Application
Bulwarks or guard rails shall be provided at the boundaries of exposed freeboard and superstructure decks, at the boundary of first tier of deckhouses and at the ends of superstructures.

1.2 Minimum height
Bulwarks, or guard rails, shall be a minimum of 1.0 m in height, measured above sheathing, and shall be constructed as required in [2.2]. Where this height would interfere with the normal operation of the ship, a lesser height may be accepted, on the basis of justifying information to be submitted.

2 Bulwarks

2.1 General

2.1.1 In the case of ships intended for the carriage of timber deck cargoes, the specific provisions of the freeboard regulations shall be complied with.

2.1.2 Openings in bulwarks shall be arranged so that the protection of the crew shall be at least equivalent to that provided by the horizontal courses in Ch.12 Sec.10 [6.1] and Ch.12 Sec.10 [6.2].
For this purpose, vertical rails or bars spaced approximately 230 mm apart may be accepted in lieu of rails or bars arranged horizontally.

2.1.3 Where bulwarks on exposed decks form wells, ample provision shall be made for freeing the decks of water, see Ch.12 Sec.10 [1] to Ch.12 Sec.10 [5].

2.2 Construction of bulwarks

2.2.1 Plating
The gross thickness of bulwark plating, at the boundaries of exposed freeboard and superstructure decks, shall not be less than that given in Table 1.

<table>
<thead>
<tr>
<th>Height of bulwark</th>
<th>Gross thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 m or more</td>
<td>Thickness required for a superstructure in the same position, obtained from Ch.6 Sec.8 [3.2]</td>
</tr>
<tr>
<td>1.0 m</td>
<td>6.0 mm</td>
</tr>
<tr>
<td>Intermediate height</td>
<td>To be determined by linear interpolation</td>
</tr>
</tbody>
</table>
2.2.2 Stays
The gross section modulus of stays, \(Z_{\text{stay-gr}}\) in \(\text{cm}^3\), calculated for section A-A and section B-B as shown in Figure 1, shall not be less than:

\[
Z_{\text{stay-gr}} = 77 \, h_{\text{blwk}}^2 \, s_{\text{stay}}
\]

where:

- \(h_{\text{blwk}}\) = height of bulwark from the top of the deck plating to the top of the rail, in m
- \(s_{\text{stay}}\) = spacing of the stays, in m.

In the calculation of the section modulus for section B-B, only the material connected to the deck shall be included. The bulb or flange of the stay may be taken into account where connected to the deck. Where the bulwark plating is connected to the sheer strake, a width of attached plating, not exceeding 600 mm, may also be included.

Figure 1 Bulwark stay

2.2.3 Where bulwarks are cut completely, stays or plate brackets of increased strength shall be fitted at the ends of openings. Openings in bulwarks shall not be situated near the end of superstructures.

Bulwark stays shall be supported by, or shall be in line with, suitable under deck stiffening. The stiffening shall be connected by double continuous fillet welds in way of bulwark stay connections.

2.2.4 At the ends of superstructures and for the distance over which their side plating is tapered into the bulwark, the latter shall have the same thickness as the side plating. Where openings are cut in the bulwark at these positions, adequate compensation shall be provided either by increasing the thickness of the plating or by other suitable means.

2.2.5 Plate bulwarks shall be stiffened at the upper edge by a suitable rail and supported either by stays or plate brackets spaced not more than 2.0 m apart.

The free edge of the stay or the plate bracket shall be stiffened.

Other arrangements may be accepted subject to special consideration.

2.2.6 Bulwark plates shall in general not be welded to side plating or deck plating within 0.6 \(L\). Such weld connections may, however, be accepted upon special consideration of design, i.e. expansion joints, thickness and material grade.
Within 0.6 \( L \) amidships, bulwarks shall be arranged such as to ensure that they are free from hull girder stresses.

Long bulwarks shall have expansion joints within 0.6 \( L \) amidships, to ensure that they are free from hull girder stresses. Expansion joints may be omitted for ships with length \( L < 65 \) m or other ships with low hull girder stresses.

2.2.7 Bulwarks shall be adequately strengthened and increased in thickness in way of mooring pipes. Cut-outs in bulwarks for gangways or other openings shall be kept clear of ends of superstructures.

2.2.8 Bulwark plating and stays shall be adequately strengthened in way of eye plates used for shrouds or other tackles in use for cargo gear operation, as well as in way of hawser holes or fairleads provided for mooring or towing.

2.2.9 Where mooring fittings subject the bulwark to large forces, the stays shall be adequately strengthened.

2.2.10 Bulwarks subjected to bow impact shall have scantlings in accordance with Ch.10 Sec.1 [3.2.2].

3 Protection of the crew

3.1 Guard rails

3.1.1 Guard rails or bulwarks shall be fitted around all exposed decks. The height of the bulwarks or guard rails shall be at least 1 metre from the deck as stated in [1.2], provided that, where this height would interfere with the normal operation of the ship, a lesser height may be approved if the flag administration is satisfied that adequate protection is provided. [1.2], provided that, where this height would interfere with the normal operation of the ship, a lesser height may be approved if the flag administration is satisfied that adequate protection is provided.

(ICLL Reg.25.2)

3.1.2 Guard rails fitted on superstructure and freeboard decks shall have at least three (3) courses. The openings below the lowest course of the guard rails shall not exceed 230 millimetres. The other courses shall be not more than 380 millimetres apart. In other locations, guard rails with at least two coursed shall be fitted.

(ICLL Reg.25.3)

3.1.3 In the case of ships with rounded gunwales the guard rail supports shall be placed on the flat of the deck.

(ICLL Reg.25.3)

3.1.4 Guard rails shall comply with the following:

a) Fixed, removable or hinged stanchions shall be fitted about 1.5 m apart.

b) At least every third stanchion shall be supported by a bracket or stay.

In lieu of at least every third stanchion supported by stay, alternatively (see Figure 2):

1) at least every third stanchion shall be of increased breadth: \( kb_s = 2.9 b_s \)

2) at least every second stanchion shall be of increased breadth: \( kb_s = 2.4 b_s \)

3) every stanchion shall be of increased breadth: \( kb_s = 1.9 b_s \).

where:

\[ b_s = \text{breadth, in mm, of normal stanchion according to the design standard.} \]
Hull equipment, supporting structure and appendages

**Figure 2 Support of stanchions**

Stanchions with increased breadth shall be aligned with member below deck, minimum 100 × 12 mm flat bar welded to deck by double continuous filled weld, unless the thickness of the deck plating exceeds 20 mm.

c) Wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths.

d) Lengths of chain may only be accepted in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

e) Wires shall be made taut by means of turnbuckles.

f) Removable or hinged stanchions shall be capable of being locked in the upright position.

(IACS UI LL47 to ICLL Reg. 25.2 and 25.3)

**3.1.5 Protection for the crew in the form of guard rails or life lines shall be provided above the deck cargo if there is no convenient passage on or below the deck of the ship.**

(ICLL Reg.25.5)

**3.1.6 Scantlings of stanchions and courses shall comply with ISO 5480, or equivalent standards.**

**3.1.7 Guard rail stanchions shall not be welded to the shell plating.**

**3.2 Gangways, walkways and passageways**

**3.2.1 Satisfactory means (in the form of guard rails, life lines, gangways or under deck passages etc.) shall be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the ship.**

(ICLL Reg.25.4)
3.2.2 Acceptable arrangements referred to in Table 2 are defined as follows:

a) A well lit and ventilated under-deck passageway (clear opening 0.8 m wide, 2.0 m high) as close as practicable to the freeboard deck, connecting and providing access to the locations in question.

b) A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship, providing a continuous platform at least 0.6 m in width and a non-slip surface, with guard rails extending on each side throughout its length. Guardrails shall be at least 1 m high with courses as required in [3.1.2], and supported by stanchions spaced not more than 1.5 m; a foot-stop shall be provided.

c) A permanent walkway at least 0.6 m in width fitted at freeboard deck level consisting of two rows of guard rails with stanchions spaced not more than 3 m. The number of courses of rails and their spacing shall be as required by [3.1.2]. On type B ships, hatchway coamings not less than 0.6 m in height may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guardrails are fitted.

d) A 10 mm minimum diameter wire rope lifeline supported by stanchions about 10 m apart, or
   A single handrail or wire rope attached to hatch coamings, continued and adequately supported between hatchways.

e) A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship:
   — located so as not to hinder easy access across the working areas of the deck;
   — providing a continuous platform at least 1.0 m in width (0.6 m will be accepted for tankers less than 100 m in length);
   — constructed of fire resistant and non-slip material;
   — fitted with guard rails extending on each side throughout its length; guard rails shall be at least 1.0 m high with courses as required by [3.1.2] and supported by stanchions spaced not more than 1.5 m.
   — provided with a foot stop on each side;
   — having openings, with ladders where appropriate, to and from the deck. Openings shall not be more than 40 m apart;
   — having shelters of substantial construction set in way of the gangway at intervals not exceeding 45 m if the length of the exposed deck to be traversed exceeds 70 m. Every such shelter shall be capable of accommodating at least one person and be so constructed as to afford weather protection on the forward, port and starboard sides.

f) A permanent and efficiently constructed walkway fitted at freeboard deck level on or as near as practicable to the centre line of the ship having the same specifications as those for a permanent gangway listed in e) except for foot-stops. On type B ships (certified for the carriage of liquids in bulk), with a combined height of hatch coaming and fitted hatch cover of together not less than 1 m in height the hatchway coamings may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guard rails are fitted.

Alternative transverse locations for c), d) and f) above, where appropriate:

1) at or near centre line of ship; or fitted on hatchways at or near centre line of ship
2) fitted on each side of the ship
3) fitted on one side of the ship, provision being made for fitting on either side
4) fitted on one side only
5) fitted on each side of the hatchways as near to the centre line as practicable.

Additional requirements:

1) In all cases where wire ropes are fitted, adequate devices shall be provided to ensure their tautness.
2) Wire ropes may only be accepted in lieu of guardrails in special circumstances and then only in limited lengths.
3) Lengths of chain may only be accepted in lieu of guardrails if fitted between two fixed stanchions.
4) Where stanchions are fitted, every 3rd stanchion shall be supported by a bracket or stay.
5) Removable or hinged stanchions shall be capable of being locked in the upright position.
6) A means of passage over obstructions, if any, such as pipes or other fittings of a permanent nature, shall be provided.
7) Generally, the width of the gangway or deck-level walkway should not exceed 1.5 m.

(ICLL Reg.25-1 and 27(8)) and SOLAS Ch. II-1/3-3.)

**Table 2 Protection of the crew**

<table>
<thead>
<tr>
<th>Type of ship</th>
<th>Locations of access in ship</th>
<th>Assigned summer freeboard</th>
<th>Acceptable arrangements according to type of freeboard assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≤ 3 000 mm</td>
<td>Type A</td>
</tr>
<tr>
<td>1.1</td>
<td>Access to midship quarters</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Between poop and bridge, or</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Between poop and deckhouse containing living accommodation or navigating equipment, or both.</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 3 000 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Access to ends</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Between poop and bow (if there is no bridge)</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Between bridge and bow, or</td>
<td>c (1)</td>
<td>c (1)</td>
</tr>
<tr>
<td>1.2.3</td>
<td>Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f (1)</td>
<td>f (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.4</td>
<td>In the case of a flush deck vessel, between crew accommodation and the forward and aft end of ship.***</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c (1)</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c (2)</td>
<td>d (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d (2)</td>
<td>d (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f (1)</td>
<td>f (2)</td>
</tr>
</tbody>
</table>

---

*All ships other than oil tankers*, chemical tankers* and gas carriers*
### Tides and freeboard

#### Hull equipment, supporting structure and appendages

**Rules for classification: Ships — DNVGL-RU-SHIP Pt.3 Ch.11. Edition January 2018**

**Hull equipment, supporting structure and appendages**

<table>
<thead>
<tr>
<th>Type of ship</th>
<th>Locations of access in ship</th>
<th>Assigned summer freeboard</th>
<th>Acceptable arrangements according to type of freeboard assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Type A</strong></td>
</tr>
<tr>
<td>Oil tankers*, chemical tankers* and gas carriers*</td>
<td>2.1 Access to bow</td>
<td>≤ (A_f+H_s)**</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>2.1.1 Between poop and bow, or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1.2 Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1.3 In the case of a flush deck vessel, between crew accommodation and the forward end of ship.</td>
<td>&gt; (A_f+H_s)**</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>2.2 Access to after end</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the case of a flush deck vessel, between crew accommodation and the after end of ship.***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Oil tankers, chemical tankers and gas carriers as defined in SOLAS Ch. II-1/2.12, VII/8.2 and VII/11.2, respectively.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>A_f =</strong> the minimum summer freeboard calculated as type A ship regardless of the type of freeboard actually assigned, in mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>H_s =</strong> the standard height of superstructure as defined in ICLL Regulation 33, in mm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*** Access to after end of ships is not applicable when crew accommodation is located aft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Acceptable arrangements referred to in this table are given in [3.2].</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Guidance note:**

Deviations from some or all of these requirements or alternative arrangements for such cases as ships with very high gangways, i.e. certain gas carriers, may be allowed subject to agreement case by case with the relevant flag administration.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
SECTION 4 APPENDAGES

Symbols
For symbols not defined in this section, see Ch.1 Sec.4.

1 General

1.1 Documents to be submitted
The documents to be submitted are indicated in Ch.1 Sec.3.

2 Bilge keel

2.1 Material, design and structural details

2.1.1 Material
The material of the bilge keel and ground bar shall be of the same yield stress as the material to which they are attached.
In addition, the following applies:
— The ground bar shall be of the same material class as the shell plate it is attached to, see Ch.3 Sec.1 [2.3].
— When the bilge keel extends over a length more than 0.15 \( L \), the bilge keel shall be of the same material class as the shell plate it is attached to, see Ch.3 Sec.1 [2.3].

![Figure 1 Bilge keel construction](image)
Figure 2 Bilge keel end design

The width of flat ground bars is to be sufficiently small to facilitate good quality welding to the shell.
2.1.2 Design

The design of single web bilge keels shall be such that failure to the web occurs before failure of the ground bar. In general, this may be achieved by ensuring the web thickness of the bilge keel does not exceed that of the ground bar.

Bilge keels of a different design, from that shown in Figure 1, shall be specially considered by the Society.

2.1.3 Ground bars

Bilge keels shall not be welded directly to the shell plating. A ground bar, or doubler, shall be fitted on the shell plating as shown in Figure 1 and Figure 2. In general, the ground bar shall be continuous. See Ch.13 Sec.1 [5.1] for welding requirements.

Figure 3 Bilge keel end design

The width of flat ground bars is to be sufficiently small to facilitate good quality welding to the shell.
The gross thickness of the ground bar shall not be less than the gross thickness of the bilge strake or 14 mm, whichever is the lesser.

2.1.4 End details
The ground bar and bilge keel ends shall be tapered or rounded. Tapering shall be gradual with a minimum ratio of 3:1, see items b) and c) in Figure 2. Rounded ends shall be as shown in item b) of Figure 2. Cut-outs on the bilge keel web, within zone "A" (see item (c) of Figure 2) are not permitted. Figure 2 are not permitted.

The end of the bilge keel web shall be not less than 50 mm and not greater than 100 mm from the end of the ground bar, see item b) of Figure 2.

Ends of the bilge keel and ground bar shall be supported by either transverse or longitudinal members inside the hull, as indicated as follows:

— Transverse support member shall be fitted between the end of the bilge keel web and the end of the ground bar, preferably close to the end of the bilge keel web, see items a), b) and c) of Figure 2.

— Longitudinal stiffener, if fitted, shall be fitted in line with the bilge keel web. It shall extend to at least the nearest transverse member forward and aft of zone "A" (see item (e) of Figure 3).

Alternative end arrangements may be accepted, provided that they are considered equivalent.

3 Propeller nozzles

3.1 General
The following requirements are applicable to fixed and steering nozzles.
For welding requirements, see Ch.13 Sec.1 [7].

3.2 Plating

3.2.1 The gross thickness of the nozzle shell plating in the propeller zone, in mm, shall not be less than:

\[ t_{gr} = 10 + 3 \alpha_p s_r \sqrt{N/k} \]

where:

- \( N = 0.01 P_S D_N \), need not be taken greater than 100
- \( P_S \) = maximum continuous output, in kW, delivered to the propeller
- \( D_N \) = inner diameter, in m, of nozzle
- \( s_r \) = distance, in m, between ring webs, shall not be taken less than 0.35 m in the formula
- \( \alpha_p \) = correction factor for the panel aspect ratio to be taken as follows but not to be taken greater than 1.0:
  \[ \alpha_p = 1.2 - \frac{b}{2a} \]
  \( a \) = length of plate panel, in mm, as defined in Ch.3 Sec.7 [2.1.1]
  \( b \) = breadth of plate panel, in mm, as defined in Ch.3 Sec.7 [2.1.1].

With reference to Figure 4, the thickness in zone I and II shall not be less than 0.7 \( t_{gr} \) and in zone III not less than 0.6 \( t_{gr} \), corrected for spacing \( s \).

The propeller zone shall be taken minimum 0.25 \( \ell_N \) (where \( \ell_N \) = length of nozzle, in m). For steering nozzles the propeller zone shall cover the variations in propeller position.
On the outer side of the nozzle, zone II shall extend beyond the aftermost ring web.

3.2.2 The thickness of ring webs and fore and aft webs shall not be taken less than \(0.6 t_{gr}\). They shall be increased in thickness in way of nozzle supports.

3.2.3 If the ship is reinforced according to an ice class notation, the part of the outer shell of the nozzle which is situated within the ice belt shall have a plate thickness not less than corresponding to the ice class requirement for the after part of the ship.

**Guidance note:**
In order to prevent corrosion and erosion of the inner surface of the nozzle, application of a corrosion resistant material in the propeller zone is recommended. All butt welds should be ground smooth.

When a corrosion resistant material is used, the plate thickness may be reduced by 15%.

---end-of-guidance-note---

3.3 Nozzle ring stiffness

3.3.1 In order to obtain a satisfactory stiffness of the nozzle ring the following requirement shall be fulfilled:

\[
I = 2.8 \rho_N D_N^3 V^2
\]

where:

- \(I\) = gross moment of inertia, in \(cm^4\), of nozzle section about the neutral axis parallel to centre line
- \(c\) = 
  \[
  \frac{28 \rho_N}{\sqrt{D_N t_{m-gr}} (n + 1)}
  \]
- \(t_{m-gr}\) = mean gross thickness of nozzle inner and outer shell plating, in mm, in propeller plane
- \(\rho_N\) = length of nozzle, see Figure 4, in m
- \(D_N\) = as given in \([3.2.1]\)
- \(V\) = maximum service speed in knots
- \(n\) = number of ring webs.

---end---

![Figure 4 Section through nozzle ring](image-url)
3.3.2 If the ship is reinforced according to class notation Ice, the parameter $V$ for the requirement given in [3.3.1] shall not be taken less than:

$$V = 14, 15, 16 \text{ and } 17 \text{ knots for qualifiers } 1C, 1B, 1A \text{ and } 1A^*, \text{ respectively.}$$

3.4 Supports

3.4.1 The nozzle shall be supported by at least two supports. The web plates and shell plates of the support structure shall be in line with web plates in the nozzle.

4 Propeller shaft brackets

4.1 General

4.1.1 The following requirements are applicable to propeller shaft brackets having two struts to support the propeller tail shaft boss. The struts may be of solid or welded type.

4.1.2 The angle between the struts shall not be less than 50 degrees.

4.2 Arrangement

4.2.1 Solid struts shall be carried continuously through the shell plating and shall be given satisfactory support by the internal ship structure.

4.2.2 Welded struts may be welded to the shell plating. The shell plating shall be reinforced, and internal brackets in line with strut plating shall be fitted. If the struts are built with a longitudinal centre plate, this plate shall be carried continuously through the shell plating. The struts shall be well rounded at fore and aft end at the transition to the hull.

4.2.3 The propeller shaft boss shall have well rounded fore and aft brackets at the connection to the struts.

4.2.4 The strut structure inside the shell shall terminate within a compartment of limited volume to reduce the effect of flooding in case of damage.

4.3 Struts

4.3.1 Solid or built-up struts of propeller shaft brackets shall comply with the following requirements:

$$h \geq 0.4 \ d$$
$$A \geq 0.4 \ d^2$$
$$W \geq 0.12 \ d^3$$

where:

$A$ = gross area of strut section in mm$^2$
$W$ = gross section modulus of section in mm$^3$. $W$ shall be calculated with reference to the neutral axis Y-Y as indicated on Figure 5
$h$ = the greatest thickness of the section in mm
\[ d = \text{propeller shaft diameter in mm.} \]

The diameter refers to shaft made of steel with a minimum specified tensile strength of 430 N/mm\(^2\).

**Figure 5 Strut section**

### 5 Elastic stern tube

#### 5.1 General

**5.1.1 Application**

Requirements in this article apply to stern tubes with long outer parts which are not supported by propeller shaft brackets.

#### 5.2 Strength analysis

**5.2.1 Loads**

For the strength analysis, following loads shall be considered:

- static loads due to structure's weight
- dynamic loads due to loss of one propeller blade at a propeller speed of 0.75 times the design speed.

**5.2.2 Permissible stress**

The maximum permissible stresses due to static loads are 0.35 \( R_{eh} \). The maximum permissible stresses due to dynamic loads are:

- 0.4 \( R_{eh} \) for \( R_{eh} = 235 \) N/mm\(^2\) and
- 0.35 \( R_{eh} \) for \( R_{eh} = 335 \) N/mm\(^2\).

For intermediate values of \( R_{eh} \), linear interpolation shall be used.
CHANGES – HISTORIC

January 2017 edition

Main changes January 2017, entering into force as from date of publication

• Sec.1 Anchoring and mooring equipment
  — Sec.1 [3.1.2]: Projected area calculation for EN of mooring. A difference from IACS had been noted and is now corrected.
  — Sec.1 Table 10: Calculation of continuous duty pull. The requirement is aligned with IACS.

• Sec.2 Supporting structure for deck equipment and fittings
  — Sec.2 [4.3]: The difference between requirement to offshore cranes and other cranes is clarified.

• Sec.3 Bulwark and protection of crew
  — Sec.3 [2.2.10]: The reference to every frame is not found appropriate for bulwark in the bow area. The text is deleted and replaced with a reference to the bow impact requirements for bulwarks.

July 2016 edition

Main changes July 2016, entering into force as from date of publication

• Sec. 1 Anchoring and mooring equipment
  — Sec.1 [3.1]: The requirement has been clarified.

October 2015 edition

This is a new document.
The rules enter into force 1 January 2016.

Amendments January 2016

• General
  — Only editorial corrections have been made.
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