FOREWORD

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CHANGES – CURRENT

This document supersedes the July 2016 edition.
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.

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

• Sec.2 Dynamic load cases
  — Sec.2 Table 6 and Sec.2 Table 12: The horizontal bending moment is lifted to be consistent with the bending moment found in global analysis.

• Sec.3 Ship motions and accelerations
  — Sec.3 [2.2.3] and Sec.3 [2.2.5]: The heave and pitch accelerations are adjusted down for ships less than 100m.

• Sec.4 Hull girder loads
  — Sec.4 [3.3.1]: The horizontal bending moment is lifted to be consistent with the bending moment found in global analysis.

• Sec.5 External loads
  — Sec.5 [1.3.5]: The BSR pressure is modified
  — Sec.5 [1.3.8]: The OSA pressure is limited at wave crest of the OSA to avoid local area with higher pressure in waterline
  — Sec.5 [2.2]: A more realistic green sea pressure is introduced for decks with recess.

• Sec.6 Internal loads
  — Sec.6 Table 1: Structural testing is required for chain locker with water to the top of chain pipe. The design pressure is updated accordingly
  — Sec.6 [1.2.7]: The minimum flooding pressure, for tight boundaries above bulkhead deck and equilibrium waterline, is removed. The application of this pressure is not justified.

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.
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SECTION 1 INTRODUCTION

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

\( S \) = static load case
\( S + D \) = static plus dynamic load case.

1 General

1.1 Application

1.1.1 Scope
This chapter provides the design loads for strength and fatigue assessments. The load combinations shall be derived for the design load scenarios as described in Sec.7. This section uses the concept of design load scenarios to specify consistent design load sets which cover the appropriate operating modes of the vessel in question.

1.1.2 Equivalent design wave
The dynamic loads associated with each dynamic load case are based on the equivalent design wave (EDW) concept. The EDW concept applies a consistent set of dynamic loads to the ship such that the specified dominant load response is equivalent to the required long term response value.

1.1.3 Probability level for strength and fatigue assessments
In this chapter, the assessments shall be understood as follows:
— strength assessment means the assessment for the strength criteria excluding fatigue. Wave induced dynamic loads for strength assessment are at a probability level of \( 10^{-8} \)
— fatigue assessment means the assessment for the fatigue criteria for the loads corresponding to the probability level of \( 10^{-2} \).

1.1.4 Dynamic load components
All dynamic load components for each dynamic load case shall be applied as simultaneous values.

1.1.5 Loads for strength assessment
The strength assessment shall be undertaken for all design load scenarios and the final assessment shall be based on the most onerous strength requirement.
Each design load scenario for strength assessment is composed of either a static (S) load case or a static + dynamic (S+D) load case, where the static and dynamic loads are dependent on the loading condition being considered.
The static and dynamic loads are defined in the following sections:
— hull girder loads in Sec.4
— external loads in Sec.5
— internal loads in Sec.6 and in Pt.5.
The EDWs for the strength assessment and the dynamic load combination factors for global loads are listed in Sec.2 [2].

1.1.6 Loads for fatigue assessment
Each design load scenario for fatigue assessment is composed of a static + dynamic (S+D) load case, where the static and dynamic loads are dependent on the loading condition being considered.
The loads are defined in the following sections:
— hull girder loads in **Sec.4**
— external loads in **Sec.5**
— internal loads in **Sec.6** and in **Pt.5**.
The EDWs for the fatigue assessment are listed in **Sec.2 [3]**.

### 1.2 Definitions

#### 1.2.1 Coordinate system
The coordinate system is defined in **Ch.1 Sec.4**.

#### 1.2.2 Sign convention for ship motions
The ship motions are defined with respect to the ship’s centre of gravity (COG) as shown in **Figure 1**, where:
— positive surge is translation in the X-axis direction (positive forward)
— positive sway is translation in the Y-axis direction (positive towards port side of ship)
— positive heave is translation in the Z-axis direction (positive upwards)
— positive roll motion is positive rotation about a longitudinal axis through the COG (starboard down and port up)
— positive pitch motion is positive rotation about a transverse axis through the COG (bow down and stern up)
— positive yaw motion is positive rotation about a vertical axis through the COG (bow moving to port and stern to starboard).

![Figure 1 Definition of positive motions](image)

#### 1.2.3 Sign convention for hull girder loads
The sign conventions of vertical bending moments, vertical shear forces, horizontal bending moments and torsional moments at any ship transverse section are as shown in **Figure 2**, namely:
— the vertical bending moments $M_{sw}$ and $M_{wv}$ are positive when they induce tensile stresses in the strength deck (hogging bending moment) and negative when they induce tensile stresses in the bottom (sagging bending moment)
— the vertical shear forces $Q_{sw}$, $Q_{wv}$ are positive in the case of downward resulting forces acting aft of the transverse section and upward resulting forces acting forward of the transverse section under consideration
— the horizontal bending moment $M_{wh}$ is positive when it induces tensile stresses in the starboard side and negative when it induces tensile stresses in the port side
— the torsional moment $M_{wt}$ is positive in the case of resulting moment acting aft of the transverse section following negative rotation around the $X$-axis, and of resulting moment acting forward of the transverse section following positive rotation around the $X$-axis.

**Figure 2** Sign conventions for shear forces $Q_{sw}$, $Q_{wv}$ and bending moments $M_{sw}$, $M_{wv}$, $M_{wh}$, and $M_{wt}$
SECTION 2 DYNAMIC LOAD CASES

Symbols

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

\( a_{\text{surge}} \), \( a_{\text{pitch}} \), \( a_{\text{sway}} \), \( a_{\text{roll}} \) = acceleration components, as defined in Sec.3

\( f_{xl} \) = ratio between X-coordinate of the load point and \( L \), to be taken as:

\[
f_{xl} = \frac{x}{L}, \text{ but shall not be taken less than 0.0 or greater than 1.0}
\]

\( f_T \) = ratio between draught at a loading condition and scantling draught, as defined in Sec.3

\( f_{tp} \) = factor depending on longitudinal position along the ship, to be taken as:

\[
f_{tp} = 1.0 \quad \text{for} \quad x/L \leq 0.5
\]

\[
f_{tp} = -1.0 \quad \text{for} \quad 0.5 < x/L
\]

\( f_{tp-OST} \) = factor for the longitudinal distribution of the torsional moment for the OST load case, as defined in Sec.4 [3.4]

\( f_{tp-OSA} \) = factor for the longitudinal distribution of the torsional moment for the OSA load case as defined in Sec.4 [3.4]

\( WS \) = weather side, side of the ship exposed to the incoming waves

\( LS \) = lee side, sheltered side of the ship away from the incoming waves

\( M_{WV} \) = vertical wave bending moment, in kNm, defined in Sec.4

\( Q_{WV} \) = vertical wave shear force, in kN, defined in Sec.4

\( M_{WH} \) = horizontal wave bending moment, in kNm, defined in Sec.4

\( M_{WT} \) = torsional wave bending moment, in kNm, defined in Sec.4

\( C_{WV} \) = load combination factor to be applied to the vertical wave bending moment

\( C_{QW} \) = load combination factor to be applied to the vertical wave shear force

\( C_{WH} \) = load combination factor to be applied to the horizontal wave bending moment

\( C_{WT} \) = load combination factor to be applied to the wave torsional moment

\( C_{XS} \) = load combination factor to be applied to the surge acceleration

\( C_{XP} \) = load combination factor to be applied to the longitudinal acceleration due to pitch

\( C_{XG} \) = load combination factor to be applied to the longitudinal acceleration due to pitch motion

\( C_{YS} \) = load combination factor to be applied to the sway acceleration

\( C_{YR} \) = load combination factor to be applied to the transverse acceleration due to roll

\( C_{YG} \) = load combination factor to be applied to the transverse acceleration due to roll motion

\( C_{ZH} \) = load combination factor to be applied to the heave acceleration

\( C_{ZR} \) = load combination factor to be applied to the vertical acceleration due to roll

\( C_{ZP} \) = load combination factor to be applied to the vertical acceleration due to pitch

\( \theta \) = roll angle, in deg, as defined in Sec.3 [2.1.1]

\( \varphi \) = pitch angle, in deg, as defined in Sec.3 [2.1.2].
1 General

1.1 Definition of dynamic load cases

1.1.1 The following EDWs shall be used to generate the dynamic load cases for structural assessment:

- HSM load cases:
  - HSM-1 and HSM-2: head sea EDWs that minimise and maximise the vertical wave bending moment amidships respectively.

- HSA load cases:
  - HSA-1 and HSA-2: head sea EDWs that maximise and minimise the head sea vertical acceleration at FP respectively.

- FSM load cases:
  - FSM-1 and FSM-2: following sea EDWs that minimise and maximise the vertical wave bending moment amidships respectively.

- BSR load cases:
  - BSR-1P and BSR-2P: beam sea EDWs that minimise and maximise the roll motion downward and upward on the port side respectively with waves from the port side.
  - BSR-1S and BSR-2S: beam sea EDWs that maximise and minimise the roll motion downward and upward on the starboard side respectively with waves from the starboard side.

- BSP load cases:
  - BSP-1P and BSP-2P: beam sea EDWs that maximise and minimise the hydrodynamic pressure at the waterline amidships on the port side respectively.
  - BSP-1S and BSP-2S: beam sea EDWs that maximise and minimise the hydrodynamic pressure at the waterline amidships on the starboard side respectively.

- OST load cases:
  - OST-1P and OST-2P: oblique sea EDWs that minimise and maximise the torsional moment at 0.25 \( L \) from the AE with waves from the port side respectively.
  - OST-1S and OST-2S: oblique sea EDWs that maximise and minimise the torsional moment at 0.25 \( L \) from the AE with waves from the starboard side respectively.

- OSA load cases:
  - OSA-1P and OSA-2P: oblique sea EDWs that maximise and minimise the pitch acceleration with waves from the port side respectively. OSA-1S and OSA-2S: oblique sea EDWs that maximise and minimise the pitch acceleration with waves from the starboard side respectively.

HSA and OSA load cases shall not be used for fatigue assessment.

Guidance note:

1) 1 and 2 denote the maximum or the minimum dominant load component for each EDW.
2) P and S denote that the weather side is on port side or starboard side respectively.

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

1.2 Application

1.2.1 The dynamic load cases described in this section shall be used for determining the dynamic loads required by the design load scenarios described in Sec.7. These dynamic load cases shall be applied to the following structural assessments:

a) Strength assessment:
   - for plating, stiffeners and primary supporting members by prescriptive methods
— for hull girder strength
— for the direct strength method (FE analysis) assessment of structural members.

b) Fatigue assessment:
— for structural details covered by simplified stress analysis
— for structural details covered by FE stress analysis.
2 Dynamic load cases for strength assessment

2.1 Description of dynamic load cases

2.1.1 Table 1 to Table 3 describe the ship motion responses and the global loads corresponding to each dynamic load case to be considered for the strength assessment.

Table 1 Ship responses for HSM, HSA and FSM load cases - strength assessment

<table>
<thead>
<tr>
<th>Load case</th>
<th>HSM-1</th>
<th>HSM-2</th>
<th>HSA-1</th>
<th>HSA-2</th>
<th>FSM-1</th>
<th>FSM-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDW</td>
<td>HSM</td>
<td>HSM</td>
<td>HSA</td>
<td>HSA</td>
<td>FSM</td>
<td>FSM</td>
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<tr>
<td>Heading</td>
<td>Head</td>
<td>Head</td>
<td>Head</td>
<td>Head</td>
<td>Following</td>
<td>Following</td>
</tr>
<tr>
<td>Effect</td>
<td>Max. bending moment</td>
<td>Max. vertical acceleration</td>
<td>Max. bending moment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VWBM</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
</tr>
<tr>
<td>HWBM</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>TM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Surge</td>
<td>To stern</td>
<td>To bow</td>
<td>To stern</td>
<td>To bow</td>
<td>To bow</td>
<td>To stern</td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td><img src="image1" alt="Diagram of surge" /></td>
<td><img src="image2" alt="Diagram of surge" /></td>
<td><img src="image3" alt="Diagram of surge" /></td>
<td><img src="image4" alt="Diagram of surge" /></td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$a_{sway}$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heave</td>
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<td>Up</td>
<td>Down</td>
<td>Up</td>
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</tr>
<tr>
<td>$a_{heave}$</td>
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<td><img src="image9" alt="Diagram of heave" /></td>
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</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pitch</td>
<td>Bow down</td>
<td>Bow up</td>
<td>Bow down</td>
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<td>Bow down</td>
</tr>
<tr>
<td>$a_{pitch}$</td>
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<td><img src="image15" alt="Diagram of pitch" /></td>
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</tbody>
</table>
### Table 2 Ship responses for BSR and BSP load cases - strength assessment

<table>
<thead>
<tr>
<th>Load case</th>
<th>BSR-1P</th>
<th>BSR-2P</th>
<th>BSR-1S</th>
<th>BSR-2S</th>
<th>BSP-1P</th>
<th>BSP-2P</th>
<th>BSP-1S</th>
<th>BSP-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDW</td>
<td>BSR</td>
<td>BSR</td>
<td></td>
<td></td>
<td>BSP</td>
<td>BSP</td>
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<td></td>
</tr>
<tr>
<td>Heading</td>
<td>Beam</td>
<td>Beam</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>Max. roll</td>
<td>Max. pressure at waterline</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>VWBM</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
</tr>
<tr>
<td>VWSF</td>
<td>Negative-aft</td>
<td>Positive-fore</td>
<td>Negative-aft</td>
<td>Positive-fore</td>
<td>Negative-aft</td>
<td>Positive-fore</td>
<td>Negative-aft</td>
<td>Positive-fore</td>
</tr>
<tr>
<td>HWBM</td>
<td>Stbd tensile</td>
<td>Port tensile</td>
<td>Port tensile</td>
<td>Stbd tensile</td>
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<td>Sway</td>
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<td><img src="image" alt="L.S → W.S" /></td>
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<tr>
<td>Roll</td>
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<td>Portside up</td>
<td>Starboard down</td>
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<td>Starboard down</td>
<td>Starboard up</td>
</tr>
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<td><img src="image" alt="W.S → L.S" /></td>
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<td>-</td>
<td>Bow down</td>
<td>Bow up</td>
<td>Bow down</td>
<td>Bow up</td>
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<tr>
<td>Load case</td>
<td>BSR-1P</td>
<td>BSR-2P</td>
<td>BSR-1S</td>
<td>BSR-2S</td>
<td>BSP-1P</td>
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### Table 3 Ship responses for OST and OSA load cases - strength assessment

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<th>OST-2S</th>
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<td>Negative-aft</td>
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<td>To bow</td>
<td>To stern</td>
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<td>To starboard</td>
<td>To starboard</td>
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<td>Up</td>
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2.2 Load combination factors

2.2.1 The load combination factors (LCFs) for the global loads and inertia load components for strength assessment are defined in:

Table 4: LCFs for HSM, HSA and FSM load cases.
Table 5: LCFs for BSR and BSP load cases.
Table 6: LCFs for OST and OSA load cases.

Table 4 Load combination factors for HSM, HSA and FSM load cases - strength assessment

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<thead>
<tr>
<th>Load component</th>
<th>LCF</th>
<th>HSM-1</th>
<th>HSM-2</th>
<th>HSA-1</th>
<th>HSA-2</th>
<th>FSM-1</th>
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<td>0.4f_T + 0.6</td>
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<td>1.0f_p</td>
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<td>0.6f_p</td>
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Table 5 Load combination factors for BSR and BSP load cases - strength assessment

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<th>BSP-1P</th>
<th>BSP-2P</th>
<th>BSP-1S</th>
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<td>$0.3 - 0.8 f_T$</td>
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<td>$C_{QW}$</td>
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<td>$(0.2 f_T - 0.1 f_p)$</td>
<td>$(0.1 - 0.2 f_T f_p)$</td>
<td>$(0.2 f_T - 0.1 f_p)$</td>
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<td>$0.2$</td>
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<td>$0.4 f_T - 0.7$</td>
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Table 6 Load combination factors for OST and OSA load cases - strength assessment

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<th>Load component</th>
<th>LCF</th>
<th>OST-1P</th>
<th>OST-2P</th>
<th>OST-1S</th>
<th>OST-2S</th>
<th>OSA-1P</th>
<th>OSA-2P</th>
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<td>$C_{WV}$</td>
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<td>$0.3 + 0.2f_T$</td>
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<td>$-0.75 + 0.5f_T$</td>
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<td>$-0.75 + 0.5f_T$</td>
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<td>$(-0.6 + 0.4f_T) f_{lp}$</td>
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<td>$0.55 + 0.2f_T$</td>
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<td>$C_{WT}$</td>
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<td>$f_{lp} - OST$</td>
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<td>$f_{lp} - OSA$</td>
<td>$f_{lp} - OSA$</td>
<td>$f_{lp} - OSA$</td>
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<td>Longitudinal accelerations</td>
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<td>$0.25 - 0.4f_T$</td>
<td>$0.25 - 0.4f_T$</td>
<td>$0.4f_T - 0.25$</td>
<td>$0.3 - 0.2f_T$</td>
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<td>$0.2f_T - 0.3$</td>
<td>$0.3 - 0.2f_T$</td>
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<td>$a_{heave}$</td>
<td>$C_{ZH}$</td>
<td>$0.2f_T - 0.05$</td>
<td>$0.05 - 0.2f_T$</td>
<td>$0.2f_T - 0.05$</td>
<td>$0.05 - 0.2f_T$</td>
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<td>$0.2f_T$</td>
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<tr>
<td>$a_{pitch-z}$</td>
<td>$C_{ZP}$</td>
<td>$0.7 - 0.3f_T$</td>
<td>$0.3f_T - 0.7$</td>
<td>$0.7 - 0.3f_T$</td>
<td>$0.3f_T - 0.7$</td>
<td>$1.0$</td>
<td>$-1.0$</td>
<td>$1.0$</td>
<td>$-1.0$</td>
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</table>
### 3 Dynamic load cases for fatigue assessment

#### 3.1 Description of dynamic load cases

**3.1.1 Table 7 to Table 9** define the ship motion responses and the global loads corresponding to each dynamic load case to be considered for fatigue assessment.

**Table 7 Ship responses for HSM and FSM load cases - fatigue assessment**

<table>
<thead>
<tr>
<th>Load case</th>
<th>HSM-1</th>
<th>HSM-2</th>
<th>FSM-1</th>
<th>FSM-2</th>
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<tbody>
<tr>
<td>EDW</td>
<td>HSM</td>
<td></td>
<td>FSM</td>
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<tr>
<td>Heading</td>
<td>Head</td>
<td></td>
<td>Following</td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>Max. bending moment</td>
<td>Max. bending moment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VWBM</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
</tr>
<tr>
<td>VWSF</td>
<td>Negative–aft</td>
<td>Positive–aft</td>
<td>Negative–aft</td>
<td>Positive–aft</td>
</tr>
<tr>
<td>HWBM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TM</td>
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</tr>
<tr>
<td>Surge</td>
<td>To stern</td>
<td>To bow</td>
<td>To bow</td>
<td>To stern</td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>Sway</td>
<td>-</td>
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<td>$a_{sway}$</td>
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<td>-</td>
</tr>
<tr>
<td>Heave</td>
<td>Down</td>
<td>Up</td>
<td>-</td>
<td>-</td>
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<tr>
<td>$a_{heave}$</td>
<td><img src="image5" alt="Diagram" /></td>
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<tr>
<td>Roll</td>
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<td>$a_{roll}$</td>
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<tr>
<td>Pitch</td>
<td>Bow down</td>
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<td>Bow up</td>
<td>Bow down</td>
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<td>$a_{pitch}$</td>
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Table 8 Ship responses for BSR and BSP load cases - fatigue assessment

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<tr>
<th>Load case</th>
<th>BSR-1P</th>
<th>BSR-2P</th>
<th>BSR-1S</th>
<th>BSR-2S</th>
<th>BSP-1P</th>
<th>BSP-2P</th>
<th>BSP-1S</th>
<th>BSP-2S</th>
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<td>EDW</td>
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<td>BSR</td>
<td>BSP</td>
<td>BSP</td>
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</tr>
<tr>
<td>Heading</td>
<td>Beam</td>
<td>Beam</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>Max. roll</td>
<td>Max. pressure at waterline</td>
<td></td>
<td></td>
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</tr>
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<td>VWBM</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
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<td>HWBM</td>
<td>Stbd tensile</td>
<td>Port tensile</td>
<td>Port tensile</td>
<td>Stbd tensile</td>
<td>Port tensile</td>
<td>Port tensile</td>
<td>Port tensile</td>
<td>Stbd tensile</td>
</tr>
<tr>
<td>TM</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>To starboard</td>
<td>To portside</td>
<td>To portside</td>
<td>To starboard</td>
<td>To portside</td>
<td>To starboard</td>
<td>To portboard</td>
<td>To portside</td>
</tr>
<tr>
<td>$a_{heave}$</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>Heave</td>
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<td>Down</td>
<td>Up</td>
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<tr>
<td>Roll</td>
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<td>Starboard down</td>
<td>Starboard up</td>
</tr>
<tr>
<td>$a_{roll}$</td>
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<td>-</td>
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<td>-</td>
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<td>$a_{pitch}$</td>
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Table 9 Ship responses for OST load cases - fatigue assessment

<table>
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<th>OST-2S</th>
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<td>Heading</td>
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<td></td>
<td>Oblique</td>
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</tr>
<tr>
<td>Effect</td>
<td></td>
<td></td>
<td>Max. torsional moment</td>
<td></td>
</tr>
<tr>
<td>VWBM</td>
<td>Sagging</td>
<td>Hogging</td>
<td>Sagging</td>
<td>Hogging</td>
</tr>
<tr>
<td>HWBM</td>
<td>Port tensile</td>
<td>Stbd tensile</td>
<td>Stbd tensile</td>
<td>Port tensile</td>
</tr>
<tr>
<td>TM</td>
<td><img src="image1" alt="Diagram" /></td>
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<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>Surge</td>
<td>To bow</td>
<td>To stern</td>
<td>To bow</td>
<td>To stern</td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
<td><img src="image7" alt="Diagram" /></td>
<td><img src="image8" alt="Diagram" /></td>
</tr>
<tr>
<td>Sway</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$a_{sway}$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heave</td>
<td>Up</td>
<td>Down</td>
<td>Up</td>
<td>Down</td>
</tr>
<tr>
<td>$a_{heave}$</td>
<td><img src="image9" alt="Diagram" /></td>
<td><img src="image10" alt="Diagram" /></td>
<td><img src="image11" alt="Diagram" /></td>
<td><img src="image12" alt="Diagram" /></td>
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<tr>
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<td>Starboard down</td>
<td>Starboard up</td>
</tr>
<tr>
<td>$a_{roll}$</td>
<td><img src="image13" alt="Diagram" /></td>
<td><img src="image14" alt="Diagram" /></td>
<td><img src="image15" alt="Diagram" /></td>
<td><img src="image16" alt="Diagram" /></td>
</tr>
<tr>
<td>Pitch</td>
<td>Bow up</td>
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<td>Bow up</td>
<td>Bow down</td>
</tr>
<tr>
<td>$a_{pitch}$</td>
<td><img src="image17" alt="Diagram" /></td>
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3.2 Load combination factors

3.2.1 The load combinations factors for the global loads and inertial load components for fatigue assessment are defined in:

Table 10: LCFs for HSM and FSM load cases.
Table 11: LCFs for BSR and BSP load cases.
Table 12: LCFs for OST load case.

Table 10 Load combination factors for HSM and FSM load cases - fatigue assessment

<table>
<thead>
<tr>
<th>Load component</th>
<th>LCF</th>
<th>HSM-1</th>
<th>HSM-2</th>
<th>FSM-1</th>
<th>FSM-2</th>
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<tbody>
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<td>Hull girderloads</td>
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<tr>
<td>$M_{WV}$</td>
<td>$C_{WV}$</td>
<td>-1</td>
<td>1</td>
<td>-0.75 - 0.2$f_T$</td>
<td>0.75 + 0.2$f_T$</td>
</tr>
<tr>
<td>$Q_{WV}$</td>
<td>$C_{QW}$</td>
<td>-1.0 $f_{lp}$</td>
<td>1.0 $f_{lp}$</td>
<td>(-0.75 - 0.2$f_T$) $f_{lp}$</td>
<td>(0.75 + 0.2$f_T$) $f_{lp}$</td>
</tr>
<tr>
<td>$M_{WH}$</td>
<td>$C_{WH}$</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$M_{WT}$</td>
<td>$C_{WT}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Longitudinal accelerations</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td>$C_{XS}$</td>
<td>0.3 - 0.2$f_T$</td>
<td>0.2$f_T$ - 0.3</td>
<td>-0.4$f_T$ + 0.2</td>
<td>0.4$f_T$ - 0.2</td>
</tr>
<tr>
<td>$a_{pitch-x}$</td>
<td>$C_{XP}$</td>
<td>-0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>$g \sin \phi$</td>
<td>$C_{XG}$</td>
<td>0.4$f_T$ + 0.4</td>
<td>-0.4$f_T$ - 0.4</td>
<td>-0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Transverse accelerations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{sway}$</td>
<td>$C_{YS}$</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$a_{roll-y}$</td>
<td>$C_{YR}$</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>$g \sin \theta$</td>
<td>$C_{YG}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical accelerations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{heave}$</td>
<td>$C_{ZH}$</td>
<td>0.8$f_T$ - 0.15</td>
<td>0.15 - 0.8$f_T$</td>
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<td>0</td>
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<td>$C_{ZR}$</td>
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<td>$C_{ZP}$</td>
<td>-0.9</td>
<td>0.9</td>
<td>0.1</td>
<td>-0.1</td>
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</table>
## Table 11: Load combination factors for BSR and BSP load cases - fatigue assessment

<table>
<thead>
<tr>
<th>Load component</th>
<th>LCF</th>
<th>BSR-1P</th>
<th>BSR-2P</th>
<th>BSR-1S</th>
<th>BSR-2S</th>
<th>BSP-1P</th>
<th>BSP-2P</th>
<th>BSP-1S</th>
<th>BSP-2S</th>
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</thead>
<tbody>
<tr>
<td>Hull girder loads</td>
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</tr>
<tr>
<td>$M_{WV}$</td>
<td>$C_{WV}$</td>
<td>0.1 – 0.2$f_T$</td>
<td>0.2$f_T$ - 0.1</td>
<td>0.1 – 0.2$f_T$</td>
<td>0.2$f_T$ - 0.1</td>
<td>0.3 – 0.8$f_T$</td>
<td>0.8$f_T$ - 0.3</td>
<td>0.3 – 0.8$f_T$</td>
<td>0.8$f_T$ - 0.3</td>
</tr>
<tr>
<td>$Q_{WV}$</td>
<td>$C_{QW}$</td>
<td>(0.1 – 0.2$f_T$ $f_{lp}$)</td>
<td>(0.2$f_T$ - 0.1) $f_{lp}$</td>
<td>(0.1 – 0.2$f_T$ $f_{lp}$)</td>
<td>(0.2$f_T$ - 0.1) $f_{lp}$</td>
<td>(0.3 – 0.8$f_T$ $f_{lp}$)</td>
<td>(0.8$f_T$ - 0.3) $f_{lp}$</td>
<td>(0.3 – 0.8$f_T$ $f_{lp}$)</td>
<td>(0.8$f_T$ - 0.3) $f_{lp}$</td>
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<tr>
<td>$M_{WH}$</td>
<td>$C_{WH}$</td>
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<td>$f_T$ - 1.1</td>
<td>$f_T$ - 1.1</td>
<td>1.1 – $f_T$</td>
<td>0.6 – 0.6$f_T$</td>
<td>0.6$f_T$ - 0.6</td>
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<td>0.6 – 0.6$f_T$</td>
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<tr>
<td>Longitudinal accelerations</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td>$C_{XS}$</td>
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<td>0</td>
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<td>$a_{pitch-x}$</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>$g \sin \phi$</td>
<td>$C_{XG}$</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>Transverse accelerations</td>
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</tr>
<tr>
<td>$a_{sway}$</td>
<td>$C_{YS}$</td>
<td>0.2 – 0.2$f_T$</td>
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<td>0.2$f_T$ - 0.2</td>
<td>0.2 – 0.2$f_T$</td>
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<td>0.95</td>
<td>0.95</td>
<td>-0.95</td>
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<tr>
<td>$a_{roll-y}$</td>
<td>$C_{VR}$</td>
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<td>-1</td>
<td>-1</td>
<td>1</td>
<td>0.3</td>
<td>-0.3</td>
<td>-0.3</td>
<td>0.3</td>
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<tr>
<td>$g \sin \theta$</td>
<td>$C_{YG}$</td>
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<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-0.2</td>
<td>0.2</td>
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<td>-0.2</td>
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<tr>
<td>Vertical accelerations</td>
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<td></td>
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<tr>
<td>$a_{heave}$</td>
<td>$C_{ZH}$</td>
<td>0.7 – 0.4$f_T$</td>
<td>0.4$f_T$ - 0.7</td>
<td>0.7 – 0.4$f_T$</td>
<td>0.4$f_T$ - 0.7</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>$a_{roll-z}$</td>
<td>$C_{ZR}$</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>0.3</td>
<td>-0.3</td>
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<tr>
<td>$a_{pitch-z}$</td>
<td>$C_{ZP}$</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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</table>
**Table 12 Load combination factors for OST load cases - fatigue assessment**

<table>
<thead>
<tr>
<th>Load component</th>
<th>LCF</th>
<th>OST-1P</th>
<th>OST-2P</th>
<th>OST-1S</th>
<th>OST-2S</th>
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<tbody>
<tr>
<td><strong>Hull girder loads</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>$M_{WV}$</td>
<td>$C_{WV}$</td>
<td>$-0.4$</td>
<td>$0.4$</td>
<td>$-0.4$</td>
<td>$0.4$</td>
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<tr>
<td>$Q_{WV}$</td>
<td>$C_{QW}$</td>
<td>$-0.4 f_T$</td>
<td>$0.4 f_T$</td>
<td>$-0.4 f_T$</td>
<td>$0.4 f_T$</td>
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<tr>
<td>$M_{WH}$</td>
<td>$C_{WH}$</td>
<td>$-1.0$</td>
<td>$1.0$</td>
<td>$1.0$</td>
<td>$-1.0$</td>
</tr>
<tr>
<td>$M_{WT}$</td>
<td>$C_{WT}$</td>
<td>$-f_v$-$OST$</td>
<td>$f_v$-$OST$</td>
<td>$f_v$-$OST$</td>
<td>$-f_v$-$OST$</td>
</tr>
<tr>
<td><strong>Longitudinal accelerations</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$a_{surge}$</td>
<td>$C_{XS}$</td>
<td>$-0.25 + 0.2f_T$</td>
<td>$0.25 - 0.2f_T$</td>
<td>$-0.25 + 0.2f_T$</td>
<td>$0.25 - 0.2f_T$</td>
</tr>
<tr>
<td>$a_{pitch-x}$</td>
<td>$C_{XP}$</td>
<td>$0.4 - 0.2f_T$</td>
<td>$-0.4 + 0.2f_T$</td>
<td>$0.4 - 0.2f_T$</td>
<td>$-0.4 + 0.2f_T$</td>
</tr>
<tr>
<td>$g \sin\varphi$</td>
<td>$C_{XG}$</td>
<td>$-0.4 + 0.2f_T$</td>
<td>$0.4 - 0.2f_T$</td>
<td>$-0.4 + 0.2f_T$</td>
<td>$0.4 - 0.2f_T$</td>
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<tr>
<td><strong>Transverse accelerations</strong></td>
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<td></td>
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<tr>
<td>$a_{sway}$</td>
<td>$C_{YS}$</td>
<td>$0$</td>
<td>$0$</td>
<td>$0$</td>
<td>$0$</td>
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<tr>
<td>$a_{roll-y}$</td>
<td>$C_{YR}$</td>
<td>$-0.4 + 0.6f_T$</td>
<td>$0.4 - 0.6f_T$</td>
<td>$0.4 - 0.6f_T$</td>
<td>$-0.4 + 0.6f_T$</td>
</tr>
<tr>
<td>$g \sin\theta$</td>
<td>$C_{YG}$</td>
<td>$0.2 - 0.3f_T$</td>
<td>$-0.2 + 0.3f_T$</td>
<td>$-0.2 + 0.3f_T$</td>
<td>$0.2 - 0.3f_T$</td>
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<tr>
<td><strong>Vertical accelerations</strong></td>
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<td></td>
</tr>
<tr>
<td>$a_{heave}$</td>
<td>$C_{ZH}$</td>
<td>$-0.05$</td>
<td>$0.05$</td>
<td>$-0.05$</td>
<td>$0.05$</td>
</tr>
<tr>
<td>$a_{roll-z}$</td>
<td>$C_{ZR}$</td>
<td>$-0.4 + 0.6f_T$</td>
<td>$0.4 - 0.6f_T$</td>
<td>$0.4 - 0.6f_T$</td>
<td>$-0.4 + 0.6f_T$</td>
</tr>
<tr>
<td>$a_{pitch-z}$</td>
<td>$C_{ZP}$</td>
<td>$0.4 - 0.2f_T$</td>
<td>$-0.4 + 0.2f_T$</td>
<td>$0.4 - 0.2f_T$</td>
<td>$-0.4 + 0.2f_T$</td>
</tr>
</tbody>
</table>
SECTION 3 SHIP MOTIONS AND ACCELERATIONS

Symbols

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

\( a_0 = \text{acceleration parameter, shall be taken as:} \)
\[ a_0 = \left(1.58 - 0.47C_\beta\right)\left(\frac{24}{\sqrt{L}} + \frac{34}{L} - \frac{600}{L^2}\right) \]
\( T_\theta = \text{roll period, in s, as defined in [2.1.1]} \)
\( \theta = \text{roll angle, in deg, as defined in [2.1.1]} \)
\( T_\phi = \text{pitch period, in s, as defined in [2.1.2]} \)
\( \phi = \text{pitch angle, in deg, as defined in [2.1.2]} \)
\( R = \text{vertical coordinate, in m, of the ship rotation centre, shall be taken as:} \)
\[ R = \min\left(\frac{D}{4} + \frac{T_{LC} \cdot D}{2}, \frac{T_{LC} \cdot D}{2}\right) \]
\( C_{XG}, C_{YS}, C_{XP}, C_{YG}, C_{YS}, C_{ZR}, C_{ZA} = \text{load combination factors, as defined in Sec.2} \)
\( a_{\text{roll-y}} = \text{transverse acceleration due to roll, in }\text{m/s}^2, \text{as defined in [3.3.2]} \)
\( a_{\text{pitch-x}} = \text{longitudinal acceleration due to pitch, in }\text{m/s}^2, \text{as defined in [3.3.1]} \)
\( a_{\text{roll-z}} = \text{vertical acceleration due to roll, in }\text{m/s}^2, \text{as defined in [3.3.3]} \)
\( a_{\text{pitch-z}} = \text{vertical acceleration due to pitch, in }\text{m/s}^2, \text{as defined in [3.3.3]} \)
\( f_T = \text{ratio between draught at a loading condition and scantling draught, shall be taken as:} \)
\[ f_T = \frac{T_{LC}}{T_{SC}}, \text{but shall not be taken less than 0.5} \]
\( T_{LC} = \text{draught, in m, amidships for the considered loading condition. In case loading condition is not defined, } T_{LC} = T_{SC} \text{ shall be applied} \)
\( x, y, z = X, Y \text{ and } Z \text{ coordinates, in m, of the considered point with respect to the coordinate system, as defined in Sec.1 [1.2.1]} \)
\( f_\beta = \text{heading correction factor, shall be taken as:} \)
for strength assessment:
\[ f_\beta = 1.0 \text{ in general} \]
\[ f_\beta = 0.8 \text{ for BSR and BSP load cases for the extreme sea loads design load scenario} \]
for fatigue assessment:
\[ f_\beta = 1.0 \]
\( f_{ps} = \text{coefficient for strength assessments which is dependant on the applicable design load scenario specified in Sec.7, and shall be taken as:} \)
\[ f_{ps} = 1.0 \text{ for extreme sea loads design load scenario} \]
\[ f_{ps} = f_r \text{ for extreme sea loads design load scenario for vessels with service restriction} \]
\[ f_{ps} = 0.8 \text{ for the ballast water exchange design load scenario} \]
\[ f_{ps} = 0.8 \cdot f_r \text{ for the ballast water exchange design load scenario for vessels with service restriction} \]
\( f_r = \text{reduction factor related to service restrictions as defined in Pt.1 Ch.2 Sec.5:} \)
1.0 for service area notation R0 (No reduction)
0.9 for service area notation R1 (10% reduction)
0.8 for service area notation R2 (20% reduction)
0.7 for service area notation R3 (30% reduction)  
0.6 for service area notation R4 (40% reduction)  
0.5 for service area notation RE (50% reduction)

\( f_{fa} \) = fatigue coefficient shall be taken as:  
\( f_{fa} = 0.9 \)

1 General

1.1 Definition

1.1.1 The ship motions and accelerations are assumed to be sinusoidal. The motion values defined by the formulae in this section are single amplitudes, i.e. half of the 'crest to trough' height.

2 Ship motions and accelerations

2.1 Ship motions

2.1.1 Roll motion

The roll period, in s, shall be taken as:

\[ T_{\theta} = \frac{2\pi k_r}{\sqrt{G^2}} \]

The roll angle, in deg, shall be taken as:

\[ \theta = \frac{9000(1.4 - 0.035T_{\theta})f_pf_{BK}}{(1.15B + 55)\pi} \]

where:

\( f_p \) = coefficient shall be taken as:

- \( f_p = f_{ps} \) for strength assessment
- \( f_p = f_{fa}(0.23 - 4f_{T}B \cdot 10^{-4}) \) for fatigue assessment

\( f_{BK} \) = shall be taken as:

- \( f_{BK} = 1.2 \) for ships without bilge keel
- \( f_{BK} = 1.0 \) for ships with bilge keel

\( k_r \) = roll radius of gyration, in m, in the considered loading condition. In case \( k_r \) has not been calculated, the following values may be used

- \( k_r = 0.39 \) \( B \) in general
- \( k_r = 0.35 \) \( B \) for tankers in ballast

For fatigue, default values are given in Ch.9

\( GM \) = metacentric height, in m, in the considered loading condition, minimum 0.05 \( B \). In case \( GM \) has not been calculated, the following values may be adopted:

- \( GM = 0.07 \) \( B \) in general
- \( GM = 0.12 \) \( B \) for tankers
- \( GM = 0.05 \) \( B \) for container ship with \( B \leq 32.2 \) m
\( GM = 0.11 \, B \) for container ship with \( B \geq 40.0 \, m \)
Linear interpolation may be used for \( 32.2 \, m \leq B \leq 40.0 \, m \)
For fatigue, default values are given in Ch.9.

2.1.2 Pitch motion
The pitch period, in s, shall be taken as:

\[
T_\varphi = \sqrt{\frac{2\pi \sqrt[4]{\varphi}}{g}}
\]

where:

\( \lambda_\varphi = 0.6(1 + f_T)L \)

The pitch angle, in deg, shall be taken as:

\[
\varphi = 920 f_p L^{-0.84} \left(1.0 + \left(\frac{2.57}{\sqrt{gL}}\right)^{1.2}\right)
\]

where:

\( f_p = \) coefficient shall be taken as:
- \( f_p = f_{ps} \) for strength assessment
- \( f_p = f_{fa} \left[0.27 - 0.02f_T \right) - (13 - 5f_T) \cdot 10^{-5}\] for fatigue assessment.

2.2 Ship accelerations at the centre of gravity

2.2.1 Surge acceleration
The longitudinal acceleration due to surge, in m/s\(^2\), shall be taken as:

\[
a_{surge} = 0.2 \left(1.6 + \frac{1.5}{\sqrt{gL}}\right)f_p a_0 g
\]

where:

\( f_p = \) coefficient shall be taken as:
- \( f_p = f_{ps} \) for strength assessment
- \( f_p = f_{fa} \left[0.27 - 0.02f_T \right) - (15 + 4f_T) \cdot 10^{-5}\] for fatigue assessment.

2.2.2 Sway acceleration
The transverse acceleration due to sway, in m/s\(^2\), shall be taken as:

\[
a_{sway} = 0.3 \left(2.25 - \frac{20}{\sqrt{gL}}\right)f_p a_0 g
\]

where:

\( f_p = \) coefficient shall be taken as:
- \( f_p = f_{ps} \) for strength assessment
\[ f_p = f_{fa}[0.24 - (6 - 2f_T)B \cdot 10^{-4}] \] for fatigue assessment.

### 2.2.3 Heave acceleration

The vertical acceleration due to heave, in m/s\(^2\), shall be taken as:

\[
a_{h\text{eave}} = 0.8(1 + 0.03v)(0.72 + \frac{2L}{700})(1.15 - \frac{6.5}{\sqrt{gl}})f_pa_0g \quad L < 100 \text{ m}
\]

\[
a_{h\text{eave}} = \left(0.4 + \frac{L}{250}\right)(1 + 0.03v)(3 - \frac{L}{50})(1.15 - \frac{6.5}{\sqrt{gl}})f_pa_0g \quad 100 \leq L < 150 \text{ m}
\]

\[
a_{h\text{eave}} = \left(1.15 - \frac{6.5}{\sqrt{gl}}\right)f_pa_0g \quad L \geq 150 \text{ m}
\]

where:

- \( v \) = unless otherwise specified in Pt.5, to be taken as:
  - 0 kt for \( L < 100 \text{ m} \)
  - 5 kt for \( L \geq 150 \text{ m} \)
  - Linear interpolation for \( L \) between 100 m and 150 m

\( f_p \) = coefficient shall be taken as:

\[
f_p = f_{ps} \quad \text{for strength assessment}
\]

\[
f_p = f_{fa}[0.27 + 0.02f_T - 17L \cdot 10^{-5}] \quad \text{for fatigue assessment.}
\]

### 2.2.4 Roll acceleration

The roll acceleration, \( a_{roll} \), in rad/s\(^2\), shall be taken as:

\[
a_{roll} = f_p \theta^2 \frac{\pi}{180} \left(\frac{2\pi}{T_R}\right)^2
\]

where:

- \( \theta \) = roll angle in deg, using \( f_p \) equal to 1.0

\( f_p \) = coefficient shall be taken as:

\[
f_p = f_{ps} \quad \text{for strength assessment}
\]

\[
f_p = f_{fa}[0.23 - 4f_TB \cdot 10^{-4}] \quad \text{for fatigue assessment.}
\]

### 2.2.5 Pitch acceleration

The pitch acceleration, in rad/s\(^2\), shall be taken as:

\[
a_{pitch} = 0.8(1 + 0.05v)f_p\left(0.72 + \frac{2L}{700}\right)\left(1.75 - \frac{22}{\sqrt{gl}}\right)\phi\left(\frac{2\pi}{180} \left(\frac{2\pi}{\phi}\right)^2\right)^2 \quad L < 100 \text{ m}
\]
\[ a_{\text{pitch}} = \left( 0.4 + \frac{L}{250} \right) \left( 1 + 0.05v \right) \left( 3 - \frac{L}{50} \right) f_p^2 \left( 1.75 - \frac{22}{\sqrt{gl}} \right) \frac{\varphi}{180} \left( \frac{2\pi}{T_p} \right)^2 \]

\[ a_{\text{pitch}} = f_p \left( 1.75 - \frac{22}{\sqrt{gl}} \right) \frac{\varphi}{180} \left( \frac{2\pi}{T_p} \right)^2 \]

where:
\[ \varphi = \text{pitch angle in deg, using } f_p \text{ equal to 1.0} \]
\[ v = \text{as defined in [2.2.3]} \]
\[ f_p = \text{coefficient shall be taken as:} \]
\[ f_p = f_{ps} \text{ for strength assessment} \]
\[ f_p = f_f a \left[ 0.28 - (5 + 6f_f) L \cdot 10^{-5} \right] \text{ for fatigue assessment.} \]

3 Accelerations at any position

3.1 General

3.1.1 The accelerations used to derive the inertial loads at any position are defined with respect to the ship fixed coordinate system. The acceleration values defined in [3.2] and [3.3] include the gravitational acceleration components due to the instantaneous roll and pitch angles.

3.1.2 The accelerations to be applied for the dynamic load cases defined in Sec.2 are given in [3.2].

3.1.3 The envelope accelerations as defined in [3.3] may be used when the maximum design acceleration values are required, for example for assessment of crane foundations, machinery foundations, etc.

3.2 Accelerations for dynamic load cases

3.2.1 Longitudinal acceleration
The longitudinal acceleration at any position for each dynamic load case, in m/s^2, shall be taken as:
\[ a_x = f_p \left[ -C_{XG} g \sin \varphi + C_{XS} a_{\text{surge}} + C_{XP} a_{\text{pitch}} (z - R) \right] \]

3.2.2 Transverse acceleration
The transverse acceleration at any position for each dynamic load case, in m/s^2, shall be taken as:
\[ a_y = f_p \left[ C_{YG} g \sin \theta + C_{YS} a_{\text{sway}} - C_{YR} a_{\text{roll}} (z - R) \right] \]

3.2.3 Vertical acceleration
The vertical acceleration at any position for each dynamic load case, in m/s^2, shall be taken as:
\[ a_z = f_p \left[ C_{ZH} a_{\text{heave}} + C_{ZR} a_{\text{roll}} \gamma - C_{ZP} a_{\text{pitch}} (x - 0.45L) \right] \]
3.3 Envelope accelerations

3.3.1 Longitudinal acceleration
The envelope longitudinal acceleration, in m/s\(^2\), at any position, shall be taken as:

\[
a_x - env = \begin{cases} 
0.595 + 0.12 \left( \frac{z - 0.875T_{LC}}{T_{LC}} \right) \sqrt{a_{surge}^2 + \left( \frac{L}{325}\sin \varphi + a_{pitch - x} \right)^2} & 0.875T_{LC} \leq z < 1.75T_{LC} \\
0.595 & z \geq 1.75T_{LC}
\end{cases}
\]

where:

\[a_{pitch - x} = \text{longitudinal acceleration due to pitch, in m/s}^2\]
\[a_{pitch - x} = a_{pitch}(z - R)\]
\[f_L = \text{correction factor based on } L:\]
\[f_L = 0.455 + 0.16 \frac{z}{T_{LC}} & \text{ for } L < 100 \text{ m}\]
\[f_L = 0.455 + 0.16 \left( \frac{L}{50} - 2 \right) + 0.16 \left( 3 - \frac{L}{50} \right) \frac{z}{T_{LC}} & \text{ for } 100 \leq L < 150 \text{ m}\]
\[f_L = 0.595 & \text{ for } L \geq 150 \text{ m}\]
\[f_v = \text{correction factor based on speed:}\]
\[f_v = 0.2v \left( -0.105 + 0.12 \frac{z - 0.875T_{LC}}{T_{LC}} \right)\]
\[v = \text{as defined in [2.2.3].}\]

3.3.2 Transverse acceleration
The envelope transverse acceleration, in m/s\(^2\), at any position, shall be taken as:

\[
a_y - env = \left( 1 - e^{-\frac{B \cdot L}{2156M}} \right) \sqrt{a_{sway}^2 + (g \sin \theta + a_{roll - y})^2}
\]

where:

\[a_{roll - y} = \text{transverse acceleration due to roll, in m/s}^2\]
\[a_{roll - y} = a_{roll}(z-R)\]

3.3.3 Vertical acceleration
The envelope vertical acceleration, in m/s\(^2\), at any position, shall be taken as:

\[
a_z - env = \sqrt{a_{heave}^2 + \left( 0.95 + e^{-\frac{L}{15}} \right) a_{pitch - z}^2 + \left( 1.2a_{roll - z} \right)^2}
\]
where:

\[ a_{pitch-z} = \text{vertical acceleration due to pitch, in m/s}^2 \]
\[ a_{pitch-z} = a_{pitch}(1.08x - 0.45L) \]

\[ a_{roll-z} = \text{vertical acceleration due to roll, in m/s}^2 \]
\[ a_{roll-z} = a_{roll} \]
SECTION 4 HULL GIRDER LOADS

Symbols

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

\( x \) = \( X \) coordinate, in m, of the calculation point with respect to the reference coordinate system defined in Sec.1 \([1.2.1]\)

\( C_w \) = wave coefficient, in m, shall be taken as:

\[ C_w = 0.0856L \quad \text{for} \quad L < 90 \]

\[ C_w = 10.75 - \left( \frac{300 - L}{100} \right)^{1.5} \quad \text{for} \quad 90 \leq L \leq 300 \]

\[ C_w = 10.75 \quad \text{for} \quad 300 < L \leq 350 \]

\[ C_w = 10.75 - \left( \frac{L - 350}{150} \right)^{1.5} \quad \text{for} \quad 350 < L \leq 500 \]

\( f_\beta \) = heading correction factor, shall be taken as:

- for strength assessment:
  \( f_\beta = 1.0 \) in general
  \( f_\beta = 0.8 \) for BSR and BSP load cases for the extreme sea loads design load scenario
  \( f_\beta = 1.0 \) for fatigue assessment:
  \( f_\beta = 1.0 \)

\( f_{ps} \) = coefficient, as defined in Sec.3

BSR, BSP, HSM, HSA, FSM, OST, OSA = dynamic load cases, as defined in Sec.2.

1 Application

1.1 General

1.1.1 The hull girder loads for the static (S) design load scenarios shall be taken as the still water loads defined in [2].

1.1.2 The total hull girder loads for the static plus dynamic (S+D) design load scenarios shall be derived for each dynamic load case and shall be taken as the sum of the still water loads defined in [2] and the dynamic loads defined in [3.5].

1.1.3 For container ships the hull girder vertical wave bending moment and shear force defined in Pt.5 Ch.2 shall apply in lieu of vertical bending moment and shear force defined in this section.

(UR S11A)
2 Still water hull girder loads

2.1 General

2.1.1 Seagoing conditions
Permissible still water bending moments and shear forces for seagoing operations shall be provided for ships with \( L > 65 \text{m} \), and may upon consideration also be requested for smaller ships. The permissible still water hull girder loads shall be given at points of local maxima for the design loading conditions. For typical cargo vessels permissible values at the following points shall be provided: at each transverse bulkhead in the cargo area, at the middle of cargo compartments, at the collision bulkhead, at the engine room forward bulkhead and at the mid-point between the forward and aft engine room bulkheads. The permissible hull girder bending moments and shear forces at any other position may be obtained by linear interpolation.

Guidance note:
It is recommended that, for initial design, the permissible hull girder hogging and sagging still water bending moments are at least 5% above the maximum still water bending moment from loading conditions in the loading manual, and the permissible hull girder shear forces are at least 10% above the maximum still water shear force from loading condition in the loading manual, to account for growth and design margins during the design and construction phase of the ship.

2.1.2 Still water loads for the fatigue assessment
The still water bending moment and shear force values and distribution shall be used for the fatigue assessment should be taken as the most typical values applicable for the loading conditions that the ship will operate in for most of its life. The definition of loading conditions to use is specified in Pt.5.

2.2 Vertical still water bending moment

2.2.1 Still water bending moment in seagoing condition
As guidance values, at a preliminary design stage, the still water bending moments, in kNm, for hogging and sagging respectively, in seagoing condition may be taken as:

Hogging conditions:

\[
M_{sw-h-min} = f_{sw}(171C_w L^2 B(C_B + 0.7)10^{-3} - M_{wv-h-mid})
\]

Sagging conditions:

\[
M_{sw-s-min} = -0.85f_{sw}(171C_w L^2 B(C_B + 0.7)10^{-3} + M_{wv-s-mid})
\]

where:

\( M_{wv-h-mid} \) = vertical wave bending moment for strength assessment amidships in hogging condition, as defined in [3.1.1] using \( f_p \) and \( f_m \) equal to 1.0

\( M_{wv-s-mid} \) = vertical wave bending moment for strength assessment amidships in sagging condition, as defined in [3.1.1] using \( f_p \) and \( f_m \) equal to 1.0

\( f_{sw} \) = distribution factor along the ship length, shall be taken as, see Figure 1:

\[
f_{sw} = 0.0 \quad \text{for} \quad x \leq 0
\]

\[
f_{sw} = 0.15 \quad \text{at} \quad x = 0.1 L
\]
\( f_{SW} = 1.0 \) for \( 0.3 \, L \leq x \leq 0.7 \, L \)
\( f_{SW} = 0.15 \) at \( x = 0.9 \, L \)
\( f_{SW} = 0.0 \) for \( x \geq L \)

Intermediate values of \( f_{SW} \) may be obtained by linear interpolation.

**Figure 1 Distribution factor \( f_{sw} \)**

2.2.2 Permissible vertical still water bending moment in seagoing condition

The permissible vertical still water bending moments, \( M_{SW-h} \) and \( M_{SW-s} \), in kNm, for hogging and sagging respectively, in seagoing condition at any longitudinal position shall envelop:

— the most severe still water bending moments calculated, in hogging and sagging conditions, respectively, for the seagoing loading conditions defined in Sec.8

— the most severe still water bending moments for the seagoing loading conditions defined in the loading manual.

2.2.3 Permissible vertical still water bending moment in harbour/sheltered water condition

The permissible vertical still water bending moments, \( M_{SW-p-h} \) and \( M_{SW-p-s} \), in kNm, for hogging and sagging respectively, in the harbour/sheltered water condition at any longitudinal position shall envelop:

— the most severe still water bending moments for the harbour/sheltered water loading conditions defined in the loading manual

— the permissible still water bending moment defined in [2.2.2].

2.3 Still water torsion moment for container ships

2.3.1 The design still water torsion moment in seagoing condition, in kNm, may be taken as:

\[
M_{st} = 20 \cdot B \cdot \sqrt{CC}
\]

where:

\[
CC = n \cdot G
\]

\[
n = \text{maximum number of 20 ft containers (TEU)}
\]
\[ G = \text{maximum mass in tonnes of each TEU the ship can carry.} \]

The still water torsion moment in seagoing condition at any longitudinal position may be taken as:

\[ M_{st-LC} = M_{st} \cdot f_{t2} \]

where:

\[ f_{t2} = \text{distribution factor along the ship length as defined in [3.4.2].} \]

### 2.4 Vertical still water shear force

#### 2.4.1 Still water shear force

As guidance values, at a preliminary design stage, the hull girder positive and negative vertical still water shear force, in kN, in seagoing condition may be taken as:

\[ Q_{sw-\text{pos\,-\,min}} = \frac{5 f_{qs} M_{sw\,-\,min}}{L} \]
\[ Q_{sw-\text{neg\,-\,min}} = \frac{-5 f_{qs} M_{sw\,-\,min}}{L} \]

where:

\[ M_{sw\,-\,min} = \text{absolute maximum of } M_{sw\,-\,h\,-\,min} \text{ and } M_{sw\,-\,s\,-\,min} \text{ with } f_{sw} = 1.0 \]

\[ f_{qs} = \text{distribution factor along the ship length. May be taken as:} \]

\[ f_{qs} = 0.0 \text{ for } x \leq 0 \]
\[ f_{qs} = 1.0 \text{ at } 0.15 L \leq x \leq 0.3 L \]
\[ f_{qs} = 0.8 \text{ for } 0.4 L \leq x \leq 0.6 L \]
\[ f_{qs} = 1.0 \text{ at } 0.7 L \leq x \leq 0.85 L \]
\[ f_{qs} = 0.0 \text{ for } x \geq L \]

Intermediate values of \( f_{qs} \) shall be obtained by linear interpolation.

#### 2.4.2 Permissible still water shear force

The permissible vertical still water shear forces, \( Q_{sw\,-\,pos} \) and \( Q_{sw\,-\,neg} \) in seagoing condition at any longitudinal position shall envelop:

— the most severe still water shear forces, positive or negative, for the seagoing loading conditions defined in Sec. 8
— the most severe still water shear forces for the seagoing loading conditions defined in the loading manual.

#### 2.4.3 Permissible still water shear force in harbour/sheltered water condition

The permissible vertical still water shear forces, \( Q_{sw\,-\,p\,-\,pos} \) and \( Q_{sw\,-\,p\,-\,neg} \), in kN, in the harbour/sheltered water and tank testing condition at any longitudinal position shall envelop:

— the most severe still water shear forces for the harbour/sheltered water loading conditions defined in the loading manual
— the permissible still water shear forces defined in [2.4.2].
3 Dynamic hull girder loads

3.1 Vertical wave bending moment

3.1.1 The vertical wave bending moments at any longitudinal position, in kNm, shall be taken as:

Hogging condition:

\[ M_{wv-h} = 0.19 f_{n\ell - vh} f_p C_w L^2 B C_B \]

Sagging condition:

\[ M_{wv-s} = -0.19 f_{n\ell - vs} f_p C_w L^2 B C_B \]

where:

- \( f_{n\ell - vh} \) = coefficient considering non-linear effects applied to hogging, shall be taken as:
  - \( f_{n\ell - h} = 1.0 \) for strength and fatigue assessment

- \( f_{n\ell - vs} \) = coefficient considering non-linear effects applied to sagging, shall be taken as:
  - \( f_{n\ell - s} = 0.58 \left( \frac{C_B + 0.7}{C_B} \right) \) for strength assessment
  - \( f_{n\ell - s} = 1.0 \) for fatigue assessment

- \( f_p \) = coefficient shall be taken as:
  - \( f_p = f_{ps} \) for strength assessment
  - \( f_p = 0.9 f_{vib}[0.27 - (6 + 4 f_T) L \cdot 10^{-5}] \) for fatigue assessment

- \( f_{vib} \) = correction for minimum contribution from hull girder vibration
  - \( = 1.10 \) for \( B \leq 28 \) m
  - \( = 1.2 \) for \( B > 40 \) m
  Linear interpolation shall be applied between \( 28 \) m \( < B \leq 40 \) m

- \( f_m \) = distribution factor for vertical wave bending moment along the ship’s length, shall be taken as:
  - \( f_m = 0.0 \) for \( x \leq 0 \)
  - \( f_m = 1.0 \) for \( 0.4 L \leq x \leq 0.65 L \)
  - \( f_m = 0.0 \) for \( x \geq L \)

Intermediate values of \( f_m \) shall be obtained by linear interpolation (see Figure 2).

For ships with high speed and or large flare in the forebody the adjustments to \( f_m \) as given in [3.1.2] apply.
The adjustment is limited to the control for buckling as given in Ch.8.
3.1.2 If required by [3.1.1] \( f_m \) shall be adjusted according to Table 1. See Figure 2.

Table 1 Adjustments to \( f_m \)

<table>
<thead>
<tr>
<th>Load condition</th>
<th>Sagging and hogging</th>
<th>Sagging only</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{AV} )</td>
<td>( \leq 0.28 )</td>
<td></td>
</tr>
<tr>
<td>( C_{AF} )</td>
<td></td>
<td>( \leq 0.40 )</td>
</tr>
<tr>
<td>( f_m )</td>
<td>No adjustment</td>
<td>No adjustment</td>
</tr>
</tbody>
</table>

1) Adjustment for \( C_{AV} \) shall not be applied when \( C_{AF} \geq 0.50 \).

\[
\begin{align*}
C_{AV} &= \frac{c_v}{\sqrt{L}} \\
C_{AF} &= \frac{c_v}{\sqrt{L}} + \frac{A_{DK} - A_{WP}}{L_o \cdot z_f} \\
c_v &= \frac{\sqrt{L}}{50}, \text{ maximum 0.2} \\
A_{DK} &= \text{projected area in the horizontal plane of upper deck (including any forecastle deck) forward of 0.2 } L \text{ from F.E.} \\
A_{WP} &= \text{area of waterplane forward of 0.2 } L \text{ from F.E. at draught } T_{SC} \\
z_f &= \text{vertical distance from summer load waterline to deckline measured at F.E.}
\end{align*}
\]

Between specified \( C_A \)-values and positions \( f_m \) shall be varied linearly.
3.2 Vertical wave shear force

3.2.1 The vertical wave shear forces at any longitudinal position, in kN, shall be taken as:

\[ Q_{wv-pos} = 0.52 \ f_{q-pos} \ f_p \ \cdot \ C_W \ \cdot \ L \ \cdot \ B \ \cdot \ C_B \]

\[ Q_{wv-neg} = -(0.52 \ f_{q-neg} \ f_p \ \cdot \ C_W \ \cdot \ L \ \cdot \ B \ \cdot \ C_B) \]

where:

\[ f_p \]

\[ f_p = \begin{cases} f_{ps} & \text{for strength assessment} \\ 0.97 \ [0.27 - (17 - 8 \ f_T) \ \cdot \ 10^{-5}] & \text{for fatigue assessment} \end{cases} \]

\[ f_{q-pos} \]

\[ f_{q-pos} = \begin{cases} 0 & \text{for } x \leq 0 \\ 0.92 \ f_{nt-h} & \text{for } 0.2 \ L \leq x \leq 0.3 \ L \\ 0.7 \ f_{nt-s} & \text{for } 0.4 \ L \leq x \leq 0.6 \ L \\ 1.0 \ f_{nt-s} & \text{for } 0.7 \ L \leq x \leq 0.85 \ L \\ 0.0 & \text{for } x \geq L \end{cases} \]

Intermediate values of \( f_{q-pos} \) shall be obtained by linear interpolation (see Figure 3)

\[ f_{q-neg} \]

\[ f_{q-neg} = \begin{cases} 0 & \text{for } x \leq 0 \\ 0.92 \ f_{nt-s} & \text{for } 0.2 \ L \leq x \leq 0.3 \ L \\ 0.7 \ f_{nt-s} & \text{for } 0.4 \ L \leq x \leq 0.6 \ L \\ 1.0 \ f_{nt-h} & \text{for } 0.7 \ L \leq x \leq 0.85 \ L \\ 0.0 & \text{for } x \geq L \end{cases} \]

Intermediate values of \( f_{q-neg} \) shall be obtained by linear interpolation, see Figure 4

\[ f_{nt-h}, f_{nt-s} \]

\[ f_{nt-h}, f_{nt-s} \] = coefficient considering non-linear effects defined in [3.1.1].

For ships with high speed and or large flare in the forebody the adjustments to \( f_{q-pos} \) and \( f_{q-neg} \) as given in [3.2.2] apply for hull girder buckling strength check in accordance with Ch.8 Sec.3.
Figure 3 Distribution factor of positive vertical shear force $f_{q-pos\text{r}}$ with and without adjustment
3.2.2 If required by [3.1.1] $f_{q\text{-pos}}$ and $f_{q\text{-neg}}$ shall be adjusted according to Table 2. See Figure 3 and Figure 4.

### Table 2 Adjustments to $f_{q\text{-pos}}$ and $f_{q\text{-neg}}$

<table>
<thead>
<tr>
<th>Load condition</th>
<th>In connection with sagging and hogging wave bending moment</th>
<th>In connection with sagging wave bending moment only</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{AV}$</td>
<td>$\leq 0.28$</td>
<td>$\geq 0.32$</td>
</tr>
<tr>
<td>$C_{AF}$</td>
<td></td>
<td>$\leq 0.40$</td>
</tr>
<tr>
<td>Multiply $f_{q\text{-pos}}$ and $f_{q\text{-neg}}$ by</td>
<td>1.0</td>
<td>1.2 between 0.7 $L$ and 0.85 $L$ from A.E.</td>
</tr>
</tbody>
</table>

1) Adjustment for $C_{AV}$ shall not be applied when $C_{AF} \geq 0.50$.

$C_{AV}$ = as defined in [3.1.2]

$C_{AF}$ = as defined in [3.1.2].

3.3 Horizontal wave bending moment

3.3.1 The horizontal wave bending moment at any longitudinal position, in kNm, shall be taken as:

$$M_{wh} = f_p(0.31 + \frac{l}{2800})f_mCWL_tT_{LC}C_B$$
where:

\[ f_p = \text{coefficient shall be taken as:} \]

\[ f_p = f_{ps} \quad \text{for strength assessment} \]
\[ f_p = 0.9 \cdot [(0.2 + 0.04 f_T) + (11 - 8 f_T) L \cdot 10^{-5}] \quad \text{for fatigue assessment} \]

\[ f_m = \text{distribution factor defined in [3.1.1].} \]

### 3.4 Wave torsional moment

#### 3.4.1 General

The factors for the longitudinal distribution of the torsional moment for the OST load case shall be taken as follows:

\[ f_{lp-OST} = 5 f_{xL} \quad \text{for } x/L < 0.2 \]
\[ f_{lp-OST} = 1.0 \quad \text{for } 0.2 \leq x/L < 0.4 \]
\[ f_{lp-OST} = -7.6 f_{xL} + 4.04 \quad \text{for } 0.4 \leq x/L < 0.65 \]
\[ f_{lp-OST} = -0.9 \quad \text{for } 0.65 \leq x/L < 0.85 \]
\[ f_{lp-OST} = 6 f_{xL} - 6 \quad \text{for } 0.85 \leq x/L \]

The factors for the longitudinal distribution of the torsional moment for the OSA load case shall be taken as follows:

\[ f_{lp-OSA} = -(0.2 + 0.3 f_T) \quad \text{for } x/L < 0.4 \]
\[ f_{lp-OSA} = -(0.2 + 0.3 f_T)(5.6 - 11.5 f_{xL}) \quad \text{for } 0.4 \leq x/L < 0.6 \]
\[ f_{lp-OSA} = 1.3(0.2 + 0.3 f_T) \quad \text{for } 0.6 \leq x/L \]

For the application in strength assessment see Sec.2 Table 6 and Sec.2 Table 12 for fatigue assessment.

#### 3.4.2 The wave torsional moment at any longitudinal position with respect to the ship baseline, in kNm, shall be taken as:

\[ M_{wt} = f_p (M_{wt1} + M_{wt2}) \]

where:

\[ M_{wt1} = 0.4 f_{t1} C_w \sqrt{\frac{L}{T_{LL}}} B^2 \cdot D \cdot C_B \]
\[ M_{wt2} = 0.22 f_{t2} C_w \cdot L \cdot B^2 \cdot C_B \]

\[ f_{t1}, f_{t2} = \text{distribution factors, taken as:} \]

\[ f_{t1} = 0 \quad \text{for } x < 0 \]
\[ f_{t1} = \left| \sin \left( \frac{360x}{L} \right) \right| \quad \text{for } 0 \leq x \leq L \]
\[ f_{t1} = 0 \quad \text{for } x > L \]
\[ f_{t2} = 0 \quad \text{for } x < 0 \]
\[ f_{t2} = \sin^2 \left( \frac{180x}{L} \right) \quad \text{for} \quad 0 \leq x \leq L \]
\[ f_{t2} = 0 \quad \text{for} \quad x > L \]

\[ f_p \quad \text{coefficient shall be taken as:} \]
\[ f_p = f_{ps} \quad \text{for strength assessment} \]
\[ f_p = 0.9 \left[ 0.2 + (5f_T - 4.25) \cdot 10^{-4} \right] \quad \text{for fatigue assessment}. \]

3.5 Hull girder loads for dynamic load cases

3.5.1 General
The dynamic hull girder loads shall be applied for the dynamic load cases defined in Sec.2, are given in [3.5.2] to [3.5.5].

3.5.2 Vertical wave bending moment
The vertical wave bending moment, \( M_{wv-LC} \), in kNm, shall be used for each dynamic load case in Sec.2, is defined in Table 3.

Table 3 Vertical wave bending moment for dynamic load cases

<table>
<thead>
<tr>
<th>Load combination factor</th>
<th>( M_{wv-LC} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{WV} \geq 0 )</td>
<td>( f_p \cdot C_{WV} \cdot M_{wv-h} )</td>
</tr>
<tr>
<td>( C_{WV} &lt; 0 )</td>
<td>( f_p \cdot C_{WV} \cdot</td>
</tr>
</tbody>
</table>

where:
\( C_{WV} \) = load combination factor for vertical wave bending moment, shall be taken as specified in Sec.2
\( M_{wv-h}, M_{wv-s} \) = hogging and sagging vertical wave bending moment taking into account the considered design load scenario, as defined in [3.1.1].

3.5.3 Vertical wave shear force
The vertical wave shear force, \( Q_{wv-LC} \), in kN, shall be used for each dynamic load case in Sec.2, is defined in Table 4.

Table 4 Vertical wave shear force for dynamic load cases

<table>
<thead>
<tr>
<th>Load combination factor</th>
<th>( Q_{wv-LC} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{QW} \geq 0 )</td>
<td>( f_p \cdot C_{QW} \cdot Q_{wv-\text{pos}} )</td>
</tr>
<tr>
<td>( C_{QW} &lt; 0 )</td>
<td>( f_p \cdot C_{QW} \cdot</td>
</tr>
</tbody>
</table>

where:
\( C_{QW} \) = load combination factor for vertical wave shear force, shall be taken as specified in Sec.2
\( Q_{vw-pos} Q_{vw-neg} \) = positive and negative vertical wave shear force taking into account the considered design load scenario, as defined in [3.2.1].

### 3.5.4 Horizontal wave bending moment

The horizontal wave bending moment, in kNm, shall be used for each dynamic load case defined in Sec.2, shall be taken as:

\[
M_{wh} = f_\beta C_{WH} M_{wh}
\]

where:

- \( C_{WH} \) = load combination factor for horizontal wave bending moment, shall be taken as specified in Sec.2
- \( M_{wh} \) = horizontal wave bending moment taking into account the appropriate design load scenario, as defined in [3.3.1].

### 3.5.5 Wave torsional moment

The wave torsional moment, in kNm, shall be used for each dynamic load case defined in Sec.2, shall be taken as:

\[
M_{wt} = f_\beta C_{WT} M_{wt}
\]

where:

- \( C_{WT} \) = load combination factor for wave torsional moment, shall be taken as specified in Sec.2
- \( M_{wt} \) = wave torsional moment taking into account the appropriate design load scenario, as defined in [3.4.2].
SECTION 5 EXTERNAL LOADS

Symbols

For symbols not defined in this section, refer to Ch.1 Sec.4.

\( \lambda \) = wave length, in m
\( B_x \) = moulded breadth at the waterline, in m, at the considered cross section
\( x, y, z \) = \( X, Y \) and \( Z \) coordinates, in m, of the load point with respect to the reference coordinate system defined in Sec.1 [1.2.1]
\( f_{xL} \) = ratio as defined in Sec.2
\( f_{yB} \) = ratio between \( Y \)-coordinate of the load point and \( B_x \), to be taken as:
\[
 f_{yB} = \frac{|2y|}{B_x} \quad \text{but not greater than 1.0.}
\]

\( f_{yB} = 0 \) when \( B_x = 0 \)
\( f_{yB1} \) = ratio between \( Y \)-coordinate of the load point and \( B \), to be taken as:
\[
 f_{yB1} = \frac{|y|}{B} \quad \text{but not greater than 1.0}
\]

\( C_w \) = wave coefficient defined in Sec.4
\( f_T \) = ratio as defined in Sec.3
\( P_{W,WL} \) = wave pressure at the waterline, kN/m\(^2\), for the considered dynamic load case
\[
 P_{W, WL} = P_W 
\quad \text{for } z = T_{LC} \quad y = B_x/2 \text{ when } y \geq 0 
\quad y = -B_x/2, \text{ when } y < 0
\]
\( h_W \) = water head equivalent to the pressure at waterline, in m, to be taken as:
\[
 h_W = \frac{P_{W, WL}}{\rho g}
\]
\( f_{ps} \) = coefficient for strength assessment, as defined in Sec.3
\( \theta \) = roll angle, in deg, as defined in Sec.3 [2.1.1]
\( T_\theta \) = roll period, in s, as defined in Sec.3 [2.1.1]
\( f_{f\alpha} \) = coefficient defined in Sec.3
\( f_\beta \) = coefficient defined in Sec.4.

1 Sea pressure

1.1 Total pressure

1.1.1 The external pressure \( P_{ex} \) at any load point of the hull, in kN/m\(^2\), for the static (S) design load scenarios, given in Sec.7, shall be taken as:
\[
 P_{ex} = P_S \quad \text{but not less than 0.}
\]
The total pressure $P_{ex}$ at any load point of the hull for the static plus dynamic (S+D) design load scenarios, given in Sec.7, shall be derived from each dynamic load case and shall be taken as:

$$P_{ex} = P_S + P_W \text{ but not less than } 0.$$  

where:

$P_S = \text{hydrostatic pressure, in kN/m}^2$, defined in [1.2]

$P_W = \text{wave pressure, in kN/m}^2$, is defined in [1.3].

### 1.2 Hydrostatic pressure

**1.2.1** The hydrostatic pressure, $P_S$ at any load point, in kN/m², is obtained from **Table 1**. See also **Figure 1**.

#### Table 1 Hydrostatic pressure, $P_S$

<table>
<thead>
<tr>
<th>Location</th>
<th>Hydrostatic pressure, $P_S$, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z \leq T_{LC}$</td>
<td>$\rho g (T_{LC} - z)$</td>
</tr>
<tr>
<td>$z &gt; T_{LC}$</td>
<td>0</td>
</tr>
</tbody>
</table>

![Figure 1 Hydrostatic pressure, $P_S$](image)

### 1.3 External dynamic pressures for strength assessment

**1.3.1 General**

The hydrodynamic pressures for each dynamic load case defined in Sec.2 [2] are defined in [1.3.2] to [1.3.8].

**1.3.2 Hydrodynamic pressures for HSM load cases**

The hydrodynamic pressures, $P_W$, for HSM-1 and HSM-2 load cases, at any load point, in kN/m², shall be obtained from **Table 2**. See also **Figure 2** and **Figure 3**.
Table 2 Hydrodynamic pressures for HSM load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z \leq T_{LC}$</td>
</tr>
<tr>
<td>HSM-1</td>
<td>$P_W = \max{-P_{HS}, \rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>HSM-2</td>
<td>$P_W = \max{P_{HS}, \rho g(z - T_{LC})}$</td>
</tr>
</tbody>
</table>

where:

$$P_{HS} = C_f T f_{ps} f_{ne} f_h k_a k_p f_{yz} C_W \sqrt{\frac{l_0 + \lambda - 125}{L}}$$

$C_f T = f_T + 0.5 - (0.7 f_T - 0.2) C_B$

$f_{ne}$ = coefficient considering non-linear effects, to be taken as:
- for extreme sea loads design load scenario:
  - $f_{nt} = 0.7$ at $f_{xl} = 0$
  - $f_{nt} = 0.9$ at $f_{xl} = 0.3$
  - $f_{nt} = 0.9$ at $f_{xl} = 0.7$
  - $f_{nt} = 0.6$ at $f_{xl} = 1$
- for ballast water exchange design load scenario:
  - $f_{nt} = 0.85$ at $f_{xl} = 0$
  - $f_{nt} = 0.95$ at $f_{xl} = 0.3$
  - $f_{nt} = 0.95$ at $f_{xl} = 0.7$
  - $f_{nt} = 0.80$ at $f_{xl} = 1$

Intermediate values are obtained by linear interpolation

$f_{yz}$ = girth distribution coefficient, to be taken as:

$$f_{yz} = C_x \cdot \frac{z}{T_{LC}} + \left(2 - C_x\right) f_{yB} + 1$$

$C_x$ = coefficient to be taken as:

$$C_x = 1.5 - \frac{|x - 0.5L|}{L}$$

$f_h$ = coefficient to be taken as:

$$f_h = 3.0 \left(1.21 - 0.66 f_T\right)$$

$k_a$ = amplitude coefficient in the longitudinal direction of the ship, to be taken as:

$$k_a = \begin{cases} 
(0.5 + f_T) \left[\left(3 - 2\sqrt{f_{yB}}\right) - \frac{20}{9} f_{xl} \left(7 - 6\sqrt{f_{yB}}\right)\right] + \frac{2}{3} (1 - f_T) & \text{for } f_{xl} < 0.15 \\
1.0 & \text{for } 0.15 \leq f_{xl} < 0.7 \\
1 + \left(f_{xl} - 0.7\right) \left[\left(\frac{40}{3} f_T - 5\right) + 2 \left(1 - f_{yB}\right) \left(\frac{18}{5} f_T (f_{xl} - 0.7) - 0.25 (2 - f_T)\right)\right] & \text{for } f_{xl} \geq 0.7 
\end{cases}$$

$\lambda$ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.6 (1 + f_T) L$
\[ k_p = \text{phase coefficient to be obtained from Table 3. Intermediate values shall be interpolated.} \]

**Table 3** \( k_p \) values for HSM load cases

<table>
<thead>
<tr>
<th>( f_{sx} )</th>
<th>0</th>
<th>0.3 – 0.1 ( f_T )</th>
<th>0.35 – 0.1 ( f_T )</th>
<th>0.8 – 0.2 ( f_T )</th>
<th>0.9 – 0.2 ( f_T )</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k_p )</td>
<td>(-0.25 f_T (1 + f_yB))</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Figure 2** Transverse distribution amidships of dynamic pressure for HSM-1, HSA-1 and FSM-1 load cases

**Figure 3** Transverse distribution amidships of dynamic pressure for HSM-2, HSA-2 and FSM-2 load cases

### 1.3.3 Hydrodynamic pressures for HSA load cases

The hydrodynamic pressures, \( P_{\text{W}} \), for HSA-1 and HSA-2 load cases at any load point, in kN/m², shall be obtained from Table 4. See also Figure 2 and Figure 3.
Table 4 Hydrodynamic pressures for HSA load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSA-1</td>
<td>$P_W = \max{-P_{HS}\rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>HSA-2</td>
<td>$P_W = \max{P_{HS}\rho g(z - T_{LC})}$</td>
</tr>
</tbody>
</table>

where:

$P_{HS} = $ as defined in [1.3.2]

$f_{n\ell} = $ coefficient considering non-linear effects, to be taken as defined in [1.3.2]

$f_{yz} = $ girth distribution coefficient as defined in [1.3.2]

$f_h = $ coefficient to be taken as:

$f_h = 2.4(1.21 - 0.66 f_T)$

$k_a = $ amplitude coefficient in the longitudinal direction of the ship, to be taken as defined in [1.3.2]

$\lambda = $ wave length of the dynamic load case, in m, as defined in [1.3.2]

$k_p = $ phase coefficient to be obtained from Table 5. Intermediate values shall be interpolated.

Table 5 $k_p$ values for HSA load cases

<table>
<thead>
<tr>
<th>$f_{xL}$</th>
<th>0</th>
<th>0.3 - 0.1 $f_T$</th>
<th>0.5 - 0.2 $f_T$</th>
<th>0.8 - 0.2 $f_T$</th>
<th>0.9 - 0.2 $f_T$</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k_p$</td>
<td>1.5 - $f_T$ - 0.5 $f_{yB}$</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

1.3.4 Hydrodynamic pressures for FSM load cases

The hydrodynamic pressures, $P_W$, for FSM-1 and FSM-2 load cases, at any load point, in kN/m², shall be obtained from Table 6. See also Figure 2 and Figure 3.

Table 6 Hydrodynamic pressures for FSM load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSM-1</td>
<td>$P_W = \max{-P_{FS}\rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>FSM-2</td>
<td>$P_W = \max{P_{FS}\rho g(z - T_{LC})}$</td>
</tr>
</tbody>
</table>

where:

$P_{FS} = C_{fT} f_{ps} f_{n\ell} f_h k_a k_p f_{yz} C_w \sqrt{\frac{I_0 + \lambda - 125}{\lambda}}$

$C_{fT} = $ coefficient to be taken as:

$C_{fT} = \left[1.0 + (1.5 - f_T)(C_B - 1.0)\right] \cdot \left(0.6 - 0.55 \frac{L - 400}{300}\right)$
\[ f_{nl} = \text{coefficient considering non-linear effects, to be taken as:} \]
\[ f_{nl} = 0.9 \text{ for extreme sea loads design load scenario.} \]
\[ f_{nl} = 0.95 \text{ for ballast water exchange design load scenarios.} \]

\[ f_{yB} = \text{girth distribution coefficient to be taken as:} \]
\[ f_{yB} = (C_x - 0.2) \frac{z}{T_{HC}} + (2 - C_x) f_{yB} + 1.2 \]

\[ C_x = \text{coefficient to be taken as:} \]
\[ C_x = 1.5 \left( 1 - \frac{1}{2} \frac{L}{f} \right) \]

\[ f_{h} = \text{coefficient to be taken as:} \]
\[ f_{h} = 2.6 \]

\[ k_{a} = \text{amplitude coefficient in the longitudinal direction of the ship, to be taken as:} \]
\[ k_{a} = \begin{cases} 
1 + (3.75 - 2f_{T})(1 - 5f_{XL})(1 - f_{yB}) & \text{for } f_{XL} < 0.2 \\
0.75 - 0.25f_{yB} & \text{for } 0.2 \leq f_{XL} < 0.9 \\
1 & \text{for } f_{XL} \geq 0.9 
\end{cases} \]

\[ \lambda = \text{wave length of the dynamic load case, in m, to be taken as:} \]
\[ \lambda = 0.6(1 + 2/3 f_{T})L \]

\[ k_{p} = \text{phase coefficient to be obtained from Table 7. Intermediate values shall be interpolated.} \]

**Table 7** $k_{p}$ values for FSM load cases

<table>
<thead>
<tr>
<th>$f_{XL}$</th>
<th>0</th>
<th>$0.35 - 0.1f_{T}$</th>
<th>$0.5 - 0.2f_{T}$</th>
<th>0.75</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k_{p}$</td>
<td>$-0.75 - 0.25f_{yB}$</td>
<td>$-1$</td>
<td>1</td>
<td>1</td>
<td>$-1$</td>
<td>$-0.75 - 0.25f_{yB}$</td>
</tr>
</tbody>
</table>

### 1.3.5 Hydrodynamic pressures for BSR load cases

The wave pressures, $P_{w}$, for BSR-1 and BSR-2 load cases, at any load point, in kN/m$^2$, shall be obtained from Table 8. See also Figure 4 and Figure 5.

**Table 8** Hydrodynamic pressures for BSR load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z \leq T_{HC}$</td>
</tr>
<tr>
<td>BSR-1P</td>
<td>$P_{w} = \max (P_{BSR}, \rho g(z - T_{HC}))$</td>
</tr>
<tr>
<td>BSR-2P</td>
<td>$P_{w} = \max (-P_{BSR}, \rho g(z - T_{HC}))$</td>
</tr>
<tr>
<td>BSR-1S</td>
<td>$P_{w} = \max (P_{BSR}, \rho g(z - T_{HC}))$</td>
</tr>
<tr>
<td>BSR-2S</td>
<td>$P_{w} = \max (-P_{BSR}, \rho g(z - T_{HC}))$</td>
</tr>
</tbody>
</table>

where:

\[ P_{BSR} = f_{p}f_{nl} \left[ 10 \sin \theta + 0.88f_{ps}C_{W} \left( \frac{l_{w} + 1.25}{L} \right) \right] \left( f_{yB} + 1 \right) \]

for BSR-1P and BSR-2P load cases.
\[ P_{BSR} = f_P f_{nl} \left[ -10 \sin \theta + 0.88 f_{ps} C_w \sqrt{\frac{L_0 + \lambda - 125}{L}} \left( f_{yB1} + 1 \right) \right] \]

for BSR-1S and BSR-2S load cases.

- \( f_{nl} \) = coefficient considering non-linear effect, to be taken as:
  - \( f_{nl} = 1 \) for extreme sea loads design load scenario
  - \( f_{nl} = 1 \) for ballast water exchange design load scenarios

- \( \lambda \) = wave length of the dynamic load case, in m, to be taken as:
  \[ \lambda = \frac{a \pi^2}{2\pi} \]

- \( P_D \) = green sea pressure on exposed deck as defined in [2.2].

**Figure 4** Transverse distribution of dynamic pressure for BSR-1P (left) and BSR-1S (right) load cases

**Figure 5** Transverse distribution of dynamic pressure for BSR-2P (left) and BSR-2S (right) load cases
1.3.6 Hydrodynamic pressures for BSP load cases

The wave pressures, $P_W$, for BSP-1 and BSP-2 load cases, at any load point, in kN/m$^2$, shall be obtained from Table 9. See also Figure 6 and Figure 7.

Table 9 Hydrodynamic pressures for BSP load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>$z \leq T_{LC}$</th>
<th>$T_{LC} &lt; z \leq h_W + T_{LC}$</th>
<th>$z &gt; h_W + T_{LC}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSP-1P</td>
<td>$P_W = \max (P_{BSP}, \rho g (z - T_{LC}))$</td>
<td>$P_W = P_{W, WL} - \rho g (z - T_{LC})$</td>
<td>$P_W = 0.0$</td>
</tr>
<tr>
<td>BSP-2P</td>
<td>$P_W = \max (-P_{BSP}, \rho g (z - T_{LC}))$</td>
<td>$P_W = 0.0$</td>
<td></td>
</tr>
<tr>
<td>BSP-1S</td>
<td>$P_W = \max (P_{BSP}, \rho g (z - T_{LC}))$</td>
<td>$P_W = P_{W, WL} - \rho g (z - T_{LC})$</td>
<td></td>
</tr>
<tr>
<td>BSP-2S</td>
<td>$P_W = \max (-P_{BSP}, \rho g (z - T_{LC}))$</td>
<td>$P_W = 0.0$</td>
<td></td>
</tr>
</tbody>
</table>

where:

$$P_{BSP} = 4.5 f_{corr1} f_{corr2} f_{\beta} f_{ps} f_{nt} f_{yz} C_w \sqrt{\frac{l_0 + \lambda - 125}{L}}$$

$\lambda$ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.2(1 + 2f_t)L$

$f_{yz}$ = girth distribution coefficient, to be obtained from Table 10

Table 10 Girth distribution coefficient, $f_{yz}$ for BSP load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>BSP-1P - BSP-2P</th>
<th>BSP-1S - BSP-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \geq 0$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$</td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$</td>
</tr>
</tbody>
</table>

$f_{nt}$ = coefficient considering non-linear effect, to be taken as:

for extreme sea loads design load scenario:

- $f_{nt} = 0.6$ at $f_{xL} = 0$
- $f_{nt} = 0.8$ at $f_{xL} = 0.3$
- $f_{nt} = 0.8$ at $f_{xL} = 0.7$
- $f_{nt} = 0.6$ at $f_{xL} = 1$

for ballast water exchange design load scenario:

- $f_{nt} = 0.6$ at $f_{xL} = 0$
- $f_{nt} = 0.8$ at $f_{xL} = 0.3$
- $f_{nt} = 0.8$ at $f_{xL} = 0.7$
- $f_{nt} = 0.6$ at $f_{xL} = 1$

Intermediate values are obtained by linear interpolation.

$f_{corr1}$ = fullness and draft correction factor, to be taken as:

$$f_{corr1} = \left[ 0.9 + \left( \frac{2T_{LC}}{T_{SC}} - 1.05 \right) \left( \frac{C_B}{0.85} - 0.85 \right) \right] \cdot \left( 1.03 - 0.16f_T \right)$$
\[ f_{\text{corr}2} = \text{ship length correction factor, to be taken as:} \]

\[ f_{\text{corr}2} = 3.5 - \frac{3.5L}{140} \quad \text{for} \quad L < 70 \]

\[ f_{\text{corr}2} = 1.75 - \frac{0.75(L - 70)}{60} \quad \text{for} \quad 70 < L < 130 \]

\[ f_{\text{corr}2} = 1 \quad \text{for} \quad 130 < L < 330 \]

\[ f_{\text{corr}2} = 1 - \frac{(L - 330)}{660} \quad \text{for} \quad L > 330 \]

**Figure 6** Transverse distribution of dynamic pressure for BSP-1P (left) and BSP-1S (right) load cases

**Figure 7** Transverse distribution of dynamic pressure for BSP-2P (left) and BSP-2S (right) load cases
1.3.7 Hydrodynamic pressures for OST load cases

The wave pressures, \( P_W \), for OST-1 and OST-2 load cases, at any load point shall be obtained, in kN/m\(^2\), from Table 11. See also Figure 8 and Figure 9.

### Table 11 Hydrodynamic pressures for OST load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( z \leq T_{LC} )</td>
</tr>
<tr>
<td>OST-1P</td>
<td>( P_W = \max (P_{OST}, \rho g (z - T_{LC})) )</td>
</tr>
<tr>
<td>OST-2P</td>
<td>( P_W = \max (-P_{OST}, \rho g (z - T_{LC})) )</td>
</tr>
<tr>
<td>OST-1S</td>
<td>( P_W = \max (P_{OST}, \rho g (z - T_{LC})) )</td>
</tr>
<tr>
<td>OST-2S</td>
<td>( P_W = \max (-P_{OST}, \rho g (z - T_{LC})) )</td>
</tr>
</tbody>
</table>

\( P_W = P_{W,WL} - \rho g (z - T_{LC}) \)

\( P_W = 0.0 \)

where:

\[
P_{OST} = 1.38 f_{corr} f_{yz} f_{nl} k_a k_p f_{yz} C_W \left[ \frac{L_0 + \lambda - 125}{L} \right]
\]

- \( f_{yz} \) = girth distribution coefficient, to be obtained from Table 12
- \( f_{nl} \) = coefficient considering non-linear effect, to be taken as:
  - \( f_{nl} = 0.8 \) for extreme sea loads design load scenario
  - \( f_{nl} = 0.9 \) for ballast water exchange design load scenarios
- \( \lambda \) = wave length of the dynamic load case, in m, to be taken as: \( \lambda = 0.45 \) \( L \)
- \( f_{corr} \) = coefficient, to be taken as:
  - \( f_{corr} = \left\{ \begin{array}{ll}
\left(1.15 - 0.3f_T\right) & \text{for } L \leq 70 \\
\left(1.15 - 0.3f_T\right) & \text{for } 70 < L \leq 150 \\
1.15 - 0.3f_T & \text{for } L > 150 
\end{array} \right. 
\)
- \( k_a \) = amplitude coefficient in the longitudinal direction of the ship, to be obtained from Table 13
- \( k_p \) = phase coefficient to be obtained from Table 14. Intermediate values shall be interpolated.

### Table 12 Girth distribution coefficient, \( f_{yz} \) for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>OST-1P - OST-2P</th>
<th>OST-1S - OST-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y \geq 0 )</td>
<td>( 5 \frac{z}{T_{LC}} + 3.5f_{yB} + 1.5 )</td>
<td>( 1.5 \frac{z}{T_{LC}} + 1.5 )</td>
</tr>
<tr>
<td>( y &lt; 0 )</td>
<td>( 1.5 \frac{z}{T_{LC}} + 1.5 )</td>
<td>( 5 \frac{z}{T_{LC}} + 3.5f_{yB} + 1.5 )</td>
</tr>
</tbody>
</table>
Table 13 $k_a$ values for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>Longitudinal position</th>
<th>$OST-1P - OST-2P$</th>
<th>$OST-1S - OST-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \geq 0$</td>
<td>$f_{xl} \leq 0.2$</td>
<td>$1 + 3.5(1 - f_{yB})(1 - 5f_{xl})$</td>
<td>$1 + [3.5 - (4f_T - 0.5)f_{yB}](1 - 5f_{xl})$</td>
</tr>
<tr>
<td></td>
<td>$0.2 &lt; f_{xl} \leq 0.8$</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>$f_{xl} &gt; 0.8$</td>
<td>1.0</td>
<td>$1 + 4(1 - f_T)(5f_{xl} - 4)f_{yB}$</td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td>$f_{xl} \leq 0.2$</td>
<td>$1 + [3.5 - (4f_T - 0.5)f_{yB}](1 - 5f_{xl})$</td>
<td>$1 + 3.5(1 - f_{yB})(1 - 5f_{xl})$</td>
</tr>
<tr>
<td></td>
<td>$0.2 &lt; f_{xl} \leq 0.8$</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>$f_{xl} &gt; 0.8$</td>
<td>$1 + 4(1 - f_T)(5f_{xl} - 4)f_{yB}$</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 14 $k_p$ values for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>$f_{xl}$</th>
<th>$OST-1P - OST-2P$</th>
<th>$OST-1S - OST-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \geq 0$</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>1.0</td>
<td>$1 + (0.75 - 1.5f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>−1.0</td>
<td>$-1 + (1.75 - 0.5f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>−1.0</td>
<td>$-1 + (1.75 - 0.5f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>$-0.1 + (1.6f_T - 1.5)f_{yB}$</td>
<td>$-0.1 + (0.25 - 0.3f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>$0.8 + 0.2f_{yB}$</td>
<td>$0.8 - (0.9f_T + 0.85)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>$-1 + f_{yB}$</td>
<td>$-1 + (0.5 - 0.5f_T)f_{yB}$</td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>$1 + (0.75 - 1.5f_T)f_{yB}$</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>$-1 + (1.75 - 0.5f_T)f_{yB}$</td>
<td>−1.0</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>$-1 + (1.75 - 0.5f_T)f_{yB}$</td>
<td>−1.0</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>$-0.1 + (0.25 - 0.3f_T)f_{yB}$</td>
<td>$-0.1 + (1.6f_T - 1.5)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>$0.8 - (0.9f_T + 0.85)f_{yB}$</td>
<td>$0.8 + 0.2f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>$-1 + (0.5 - 0.5f_T)f_{yB}$</td>
<td>$-1 + f_{yB}$</td>
</tr>
</tbody>
</table>
1.3.8 Hydrodynamic pressures for OSA load cases

The wave pressures, $P_W$, for OSA-1 and OSA-2 load cases, at any load point, in kN/m$^2$, shall be obtained from Table 15. See also Figure 10 and Figure 11.

**Table 15 Hydrodynamic pressures for OSA load cases**

<table>
<thead>
<tr>
<th>Load case</th>
<th>$z \leq T_{LC}$</th>
<th>$T_{LC} &lt; z \leq h_W + T_{LC}$</th>
<th>$z &gt; h_W + T_{LC}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSA-1P</td>
<td>$P_W = \max (P_{OSA}, \rho g (z - T_{LC}))$</td>
<td>$P_W = P_{W, WL} - \rho g (z - T_{LC})$</td>
<td>$P_W = 0.0$</td>
</tr>
<tr>
<td>OSA-2P</td>
<td>$P_W = \max (-P_{OSA}, \rho g (z - T_{LC}))$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSA-1S</td>
<td>$P_W = \max (P_{OSA}, \rho g (z - T_{LC}))$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSA-2S</td>
<td>$P_W = \max (-P_{OSA}, \rho g (z - T_{LC}))$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where:

$$P_{OSA} = 0.81 f_{corr} f_{ps} f_{nl} k_d k_p f_{yz} C_W \left( \frac{l_0 + \lambda - 125}{L} \right)^{1 + 0.5f_T}$$
\( \lambda = \) wave length of the dynamic load case, in m, to be taken as: \( \lambda = 0.7 \ L \)

\( f_{\text{corr}} = \) fullness and draft correction factor, to be taken as:

\[
f_{\text{corr}} = (1.08 - 0.18f_T)[1.25 + \ln(C_B)]
\]

for \( L < 80 \)

\[
f_{\text{corr}} = (1.08 - 0.18f_T)[1.25 + \ln(C_B)]\left[1 - \left(\frac{L}{20} - 4\right)\left(1 - \sin\left(\frac{25T_{LC}}{L}\right)\right)\right]
\]

for \( 80 \leq L < 100 \)

\[
f_{\text{corr}} = (1.08 - 0.18f_T)[1.25 + \ln(C_B)]\sin\left(\frac{25T_{LC}}{L}\right)
\]

for \( L \geq 100 \)

\( f_{nt} = \) coefficient considering non-linear effect, to be taken as:

for extreme sea loads design load scenario:

\[
f_{nt} = 0.5 \text{ at } f_{xL} = 0
\]

\[
f_{nt} = 0.8 \text{ at } f_{xL} = 0.3
\]

\[
f_{nt} = 0.8 \text{ at } f_{xL} = 0.7
\]

\[
f_{nt} = 0.6 \text{ at } f_{xL} = 1
\]

for ballast water exchange design load scenario:

\[
f_{nt} = 0.75 \text{ at } f_{xL} = 0
\]

\[
f_{nt} = 0.9 \text{ at } f_{xL} = 0.3
\]

\[
f_{nt} = 0.9 \text{ at } f_{xL} = 0.7
\]

\[
f_{nt} = 0.8 \text{ at } f_{xL} = 1
\]

Intermediate values are obtained by linear interpolation.

\( f_{yz} = \) girth distribution coefficient, to be obtained from Table 16

\( k_a = \) amplitude coefficient in the longitudinal direction of the ship, to be obtained from Table 17

\( k_p = \) phase coefficient to be obtained from Table 18. Intermediate values shall be interpolated.

**Table 16 Girth distribution coefficient, \( f_{yz} \) for OSA load cases**

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>OSA-1P - OSA-2P</th>
<th>OSA-1S - OSA-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y \geq 0 )</td>
<td>( 5.5\frac{z}{T_{LC}} + 5.3f_{yB} + 2.2 )</td>
<td>( 0.9\frac{z}{T_{LC}} + 0.4f_{yB} + 2.2 )</td>
</tr>
<tr>
<td>( y &lt; 0 )</td>
<td>( 0.9\frac{z}{T_{LC}} + 0.4f_{yB} + 2.2 )</td>
<td>( 5.5\frac{z}{T_{LC}} + 5.3f_{yB} + 2.2 )</td>
</tr>
</tbody>
</table>
Figure 10 Transverse distribution of dynamic pressure amidships for OSA-1P (left) and OSA-1S (right) load cases

Figure 11 Transverse distribution of dynamic pressure amidships for OSA-2P (left) and OSA-2S (right) load cases
### Table 17 \( k_a \) values for OSA load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>Longitudinal position</th>
<th>OSA-1P - OSA-2P</th>
<th>Longitudinal position</th>
<th>OSA-1S - OSA-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y \geq 0 )</td>
<td>( f_{xl} &lt; 0.275 )</td>
<td>( \min{k_{a3}; 1.05} )</td>
<td>( f_{xl} &lt; 0.35 )</td>
<td>( 1 + 4(f_T - 0.75)f_{yB} + 1.2f_{yB}\cos[90(5f_{xl} - 0.75)] )</td>
</tr>
<tr>
<td></td>
<td>( 0.275 &lt; f_{xl} \leq 0.7 )</td>
<td>( \min{k_{a1}; 1.05} )</td>
<td>( 0.35 &lt; f_{xl} \leq 0.65 )</td>
<td>( k_{a2} )</td>
</tr>
<tr>
<td></td>
<td>( f_{xl} &gt; 0.7 )</td>
<td>( k_{a1} + \left(1.9f_T - 2.05\right)f_{yB} ) ( \cos\left[\frac{180(f_{xl} - 0.04)}{0.6}\right] )</td>
<td>( f_{xl} &gt; 0.65 )</td>
<td>( k_{a2} + 36(f_{xl} - 0.65)^2f_{yB} )</td>
</tr>
<tr>
<td>( y &lt; 0 )</td>
<td>( f_{xl} &lt; 0.35 )</td>
<td>( 1 + 4(f_T - 0.75)f_{yB} + 1.2f_{yB}\cos[90(5f_{xl} - 0.75)] )</td>
<td>( f_{xl} &lt; 0.275 )</td>
<td>( \min{k_{a3}; 1.05} )</td>
</tr>
<tr>
<td></td>
<td>( 0.35 &lt; f_{xl} \leq 0.65 )</td>
<td>( k_{a2} )</td>
<td>( 0.275 &lt; f_{xl} \leq 0.7 )</td>
<td>( \min{k_{a1}; 1.05} )</td>
</tr>
<tr>
<td></td>
<td>( f_{xl} &gt; 0.65 )</td>
<td>( k_{a2} + 36(f_{xl} - 0.65)^2f_{yB} ) ( \cos\left[\frac{180(f_{xl} - 0.04)}{0.6}\right] )</td>
<td>( f_{xl} &gt; 0.7 )</td>
<td>( k_{a1} + \left(1.9f_T - 2.05\right)f_{yB} ) ( \cos\left[\frac{180(f_{xl} - 0.04)}{0.6}\right] )</td>
</tr>
</tbody>
</table>

where:

\[
k_{a1} = 1 + 0.2\left(2 - f_T\right)f_{yB}\sin\left[180\left(0.5 + \frac{f_{xl} - 0.275}{0.425}\right)\right] + 0.09
\]

\[
k_{a2} = 1 - 2\left(f_T - 0.75\right)f_{yB}\left(3.75 - 5f_{xl}\right)\sin\left[60\left(10f_{xl} - 5\right)\right]
\]

\[
k_{a3} = k_{a1} + \left(0.3f_T - 1.15\right)f_{yB}\cos\left[180\left(f_{xl} - 0.05\right)\right] / 0.45
\]
### Table 18 $k_p$ values for OSA load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>$f_{xL} = x/L$</th>
<th>OSA-1P and OSA-2P</th>
<th>OSA-1S and OSA-2S&lt;sup&gt;1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \geq 0$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>$0.75 - 0.5f_yB$</td>
<td>$0.75$</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>$f_T - 0.25 + (1.25 - f_T)f_yB$</td>
<td>$f_T - 0.25 + (0.35f_T - 0.47)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.35</td>
<td>$1$</td>
<td>$1 + (2.7f_T - 3.2)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>$1.25 - 0.5f_T + (0.5f_T - 0.25)f_yB$</td>
<td>$1.25 - 0.5f_T + (2.7f_T - 3.2)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>$1.5 - f_T + (f_T - 1.07)f_yB$</td>
<td>$1.5 - f_T + (2.7f_T - 3.2)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_yB$</td>
<td>$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_yB$</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_yB$</td>
<td>$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_yB$</td>
<td></td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>0.75</td>
<td>$0.75 - 0.5f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>$f_T - 0.25 + (0.35f_T - 0.47)f_yB$</td>
<td>$f_T - 0.25 + (1.25 - f_T)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.35</td>
<td>$1 + (2.7f_T - 3.2)f_yB$</td>
<td>$1$</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>$1.25 - 0.5f_T + (2.7f_T - 3.2)f_yB$</td>
<td>$1.25 - 0.5f_T + (0.5f_T - 0.25)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>$1.5 - f_T + (f_T - 1.07)f_yB$</td>
<td>$1.5 - f_T + (2.7f_T - 3.2)f_yB$</td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_yB$</td>
<td>$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_yB$</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_yB$</td>
<td>$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_yB$</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup) $k_p$ shall not be taken less than −1.0 or greater than 1.0.

$k_p$ for other $f_{xL}$ shall be linearly interpolated.

### 1.3.9 Envelope of dynamic pressure

The envelope of dynamic pressure at any point, $P_{ex-max}$, shall be taken as the greatest pressure obtained from any of the load cases determined by [1.3.2] to [1.3.8].

### 1.4 External dynamic pressures for fatigue assessments

#### 1.4.1 General

The external pressure $P_{ex}$ at any load point of the hull for the fatigue static plus dynamic (F:S+D) design load scenario, shall be derived for each fatigue dynamic load case and shall be taken as:

$$P_{ex} = P_S + P_W$$

but not less than 0.

where:

- $P_S$ = hydrostatic pressure, in kN/m$^2$, defined in [1.2]
- $P_W$ = hydrodynamic pressure, in kN/m$^2$, is defined in [1.4.2] to [1.4.6].

#### 1.4.2 Hydrodynamic pressures for HSM load cases

The hydrodynamic pressures, $P_W$, for load cases HSM-1 and HSM-2, at any load point, in kN/m$^2$, shall be obtained from Table 19.
Table 19 Hydrodynamic pressures for HSM load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
<th>( z \leq T_{LC} )</th>
<th>( T_{LC} &lt; z \leq 2h_w + T_{LC} )</th>
<th>( z &gt; 2h_w + T_{LC} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSM-1</td>
<td>( P_w = \max{-P_{HS}, \rho g(z - T_{LC})} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSM-2</td>
<td>( P_w = \max{P_{HS}, \rho g(z - T_{LC})} )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where:

\[
P_{HS} = f_p f_{yz} k_a k_p f_{yz} C_w \frac{(T_{LC} + \lambda - 125)}{L}
\]

\( f_{yz} = \) girth distribution coefficient, to be taken as:

\[
f_{yz} = \frac{z}{T_{LC}} + f_{yB} + 1
\]

\( f_h = \) coefficient to be taken as: \( f_h = 2.75(1.21 - 0.66f_T) \)

\( f_p = \) coefficient to be taken as:

\[
f_p = f_p a \left[ (0.21 + 0.02f_T) + (6 - 4f_T)L \cdot 10^{-5} \right]
\]

\( k_a = \) amplitude coefficient in the longitudinal direction of the ship, to be taken as:

\[
k_a = 1 + 3f_T - (1 + f_T)f_{yB} + \left( 5(1 + f_T)f_{yB} - 15f_T \right) f_{xL}
\]

\[
k_a = 1.0 \quad \text{for } f_{xL} < 0.2
\]

\[
k_a = 1 + \left( f_{xL} - 0.6 \right) \left( 13.5 - 3.5f_T \right) f_{yB} + (14.5f_T - 17) + 40(1 - f_{yB})(f_{xL} - 0.06)
\]

\[
k_a = 1 \quad \text{for } 0.2 \leq f_{xL} < 0.6
\]

\[
k_a = 1 + \left( f_{xL} - 0.6 \right) \left[ (13.5 - 3.5f_T)FyB + (14.5f_T - 17) + 40(1 - f_{yB})(f_{xL} - 0.06) \right]
\]

\[
k_a = 0.9 - 0.4f_T \quad \text{for } f_{xL} \geq 0.6
\]

\( \lambda = \) wave length of the dynamic load case, in m, to be taken as: \( \lambda = 0.6(1 + f_T)L \)

\( k_p = \) phase coefficient to be obtained from Table 20. Intermediate values shall be interpolated.

Table 20 \( k_p \) values for HSM load cases

<table>
<thead>
<tr>
<th>( f_{xL} )</th>
<th>( k_p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>((1 - f_T) + (0.5 - f_T)f_{yB})</td>
</tr>
<tr>
<td>0.3 – 0.1 ( f_T )</td>
<td>-1</td>
</tr>
<tr>
<td>0.5 – 0.2 ( f_T )</td>
<td>1</td>
</tr>
<tr>
<td>0.9 – 0.4 ( f_T )</td>
<td>1</td>
</tr>
<tr>
<td>0.9 – 0.2 ( f_T )</td>
<td>-1</td>
</tr>
<tr>
<td>1.0</td>
<td>-1</td>
</tr>
</tbody>
</table>

1.4.3 Hydrodynamic pressures for FSM load cases

The hydrodynamic pressures, \( P_w \), for FSM-1 and FSM-2 load cases, at any load point, in kN/m², shall be obtained from Table 21.
Table 21 Hydrodynamic pressures for FSM load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z \leq T_{LC}$</td>
</tr>
<tr>
<td>FSM-1</td>
<td>$P_w = \max{-P_{FS}, \rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>FSM-2</td>
<td>$P_w = \max{P_{FS}, \rho g(z - T_{LC})}$</td>
</tr>
</tbody>
</table>

where:

\[ P_{FS} = f_p f_h k_a f_{yz} C_W \frac{L_0 + \lambda - 125}{L} \]

- $f_{yz}$ = girth distribution coefficient, to be taken as:
  \[ f_{yz} = \frac{y}{T_{LC}} + f_{yB} + 1 \]
- $f_h$ = coefficient to be taken as: $f_h = 2.6$
- $f_p$ = coefficient to be taken as: $f_p = f_a \left[0.21 + 0.02 f_T + (6 - 4 f_T) L \cdot 10^{-5}\right]$
- $k_a$ = amplitude coefficient in the longitudinal direction of the ship, to be taken as:
  \[ k_a = 1 + (3.5 - 2 f_T) (1 - f_{xl}) (1 - f_{yB}) \] for $f_{xl} < 0.2$
  \[ k_a = 1.0 \] for $0.2 \leq f_{xl} < 0.9$
  \[ k_a = 1 + 15 (1 - f_{yB}) (f_{xl} - 0.9) \] for $f_{xl} \geq 0.9$
- $f_T$ = wave length of the dynamic load case, in m, to be taken as:
  \[ f_T = 0.6 \left(1 + \frac{2}{3 f_T}\right) L \]
- $k_p$ = phase coefficient to be obtained from Table 22. Intermediate values shall be interpolated.

Table 22 $k_p$ values for FSM load cases

<table>
<thead>
<tr>
<th>$f_{xl}$</th>
<th>$k_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$-0.75 - 0.25 f_{yB}$</td>
</tr>
<tr>
<td>0.35 - 0.1$f_T$</td>
<td>$-1$</td>
</tr>
<tr>
<td>0.5 - 0.2$f_T$</td>
<td>$1$</td>
</tr>
<tr>
<td>0.75</td>
<td>$1$</td>
</tr>
<tr>
<td>0.9 - 0.1$f_T$</td>
<td>$-1$</td>
</tr>
<tr>
<td>1.0</td>
<td>$-0.5 - 0.5 f_{yB}$</td>
</tr>
</tbody>
</table>

1.4.4 Hydrodynamic pressures for BSR load cases

The hydrodynamic pressures, $P_w$, for BSR-1 and BSR-2 load cases, at any load point, in kN/m², shall be obtained from Table 23.
Table 23 Hydrodynamic pressures for BSR load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z \leq T_{LC}$</td>
</tr>
<tr>
<td>BSR-1P</td>
<td>[ P_w = \max {P_{BSR} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSR-2P</td>
<td>[ P_w = \max {-P_{BSR} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSR-1S</td>
<td>[ P_w = \max {P_{BSR} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSR-2S</td>
<td>[ P_w = \max {-P_{BSR} \rho g(z - T_{LC})} ]</td>
</tr>
</tbody>
</table>

where:

\[ P_{BSR} = 10 \sin \theta + 0.88 f_p C_w \frac{l_d + \lambda - 125}{l_d} (f_{yB1} + 1) \]

for BSR-1P and BSR-2P load cases.

\[ P_{BSR} = -10 \sin \theta + 0.88 f_p C_w \frac{l_d + \lambda - 125}{l_d} (f_{yB1} + 1) \]

for BSR-1S and BSR-2S load cases.

$f_p = \text{coefficient to be taken as: } f_p = f_{fa}[(0.21 + 0.04 f_T - (12 f_T - 2) B \cdot 10^{-4}]$

$\lambda = \text{wave length of the dynamic load case, in m, to be taken as: }$

\[ \lambda = \frac{g}{2 \pi T_{th}} \]

1.4.5 Hydrodynamic pressures for BSP load cases

The wave pressures, $P_w$, for BSP-1 and BSP-2 load cases, at any load point, in kN/m², shall be obtained from Table 24.

Table 24 Hydrodynamic pressures for BSP load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z \leq T_{LC}$</td>
</tr>
<tr>
<td>BSP-1P</td>
<td>[ P_w = \max {P_{BSP} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSP-2P</td>
<td>[ P_w = \max {-P_{BSP} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSP-1S</td>
<td>[ P_w = \max {P_{BSP} \rho g(z - T_{LC})} ]</td>
</tr>
<tr>
<td>BSP-2S</td>
<td>[ P_w = \max {-P_{BSP} \rho g(z - T_{LC})} ]</td>
</tr>
</tbody>
</table>
where:

$$P_{BSP} = 4.5 f_{corr1} f_{corr2} f_p f_{yz} C_w \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

$\lambda$ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.2(1 + 2 f_T) L$

$f_{corr1}$ = fullness and draft correction factor, to be taken as:

$$f_{corr1} = 0.9 + \left( \frac{C_B}{0.85} - 1.05 \right) \left( 1.03 - 0.16 f_T \right)$$

$f_{corr2}$ = ship length correction factor, to be taken as:

$$f_{corr2} = \begin{cases} 
3.5 - \frac{3.5L}{140} & \text{for } L < 70 \\
1.75 - \frac{0.75(L - 70)}{60} & \text{for } 70 \leq L < 130 \\
1 & \text{for } 130 \leq L \leq 330 \\
1 - \frac{L - 330}{660} & \text{for } L > 330
\end{cases}$$

$f_p$ = coefficient to be taken as:

$$f_p = f_y \left[ 0.2 + \left( 8 + 16 f_T \right) \cdot 10^{-3} \right]$$

$f_{yz}$ = girth distribution coefficient, to be obtained from Table 25.

**Table 25 Girth distribution coefficient, $f_{yz}$ for BSP load cases**

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>$BSP-1P; BSP-2P$</th>
<th>$BSP-1S; BSP-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \geq 0$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_L} + 2.5 f_y B_1 + 0.5$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_L} + \frac{1}{2} f_y B_1 + 0.5$</td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_L} + \frac{1}{2} f_y B_1 + 0.5$</td>
<td>$f_{yz} = \frac{2}{3} \frac{z}{T_L} + 2.5 f_y B_1 + 0.5$</td>
</tr>
</tbody>
</table>

**1.4.6 Hydrodynamic pressures for OST load cases**

The wave pressures, $P_w$, for OST-1 and OST-2 load cases, at any load point, in kN/m$^2$, shall be obtained from Table 26.
Table 26 Hydrodynamic pressures for OST load cases

<table>
<thead>
<tr>
<th>Load case</th>
<th>Wave pressure, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$z ≤ T_{LC}$</td>
</tr>
<tr>
<td>OST-1P</td>
<td>$P_w = \max{P_{OST}, \rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>OST-2P</td>
<td>$P_w = \max{-P_{OST}, \rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>OST-1S</td>
<td>$P_w = \max{P_{OST}, \rho g(z - T_{LC})}$</td>
</tr>
<tr>
<td>OST-2S</td>
<td>$P_w = \max{-P_{OST}, \rho g(z - T_{LC})}$</td>
</tr>
</tbody>
</table>

where:

$$P_{OST} = 1.38(1.15 - 0.3f_T)f_p k_a k_p f_{yz} C_w \sqrt{\frac{L_0 + \lambda - 125}{\lambda}}$$

$f_{yz}$ = girth distribution coefficient, to be obtained from Table 27

Table 27 Girth distribution coefficient, $f_{yz}$ for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>$OST-1P; OST-2P$</th>
<th>$OST-1S; OST-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y ≥ 0$</td>
<td>$\frac{z}{T_{LC}} + 3.3f_yB + 1.7$</td>
<td>$\frac{z}{T_{LC}} + 0.3f_yB + 1.7$</td>
</tr>
<tr>
<td>$y &lt; 0$</td>
<td>$\frac{z}{T_{LC}} + 0.3f_yB + 1.7$</td>
<td>$\frac{z}{T_{LC}} + 3.3f_yB + 1.7$</td>
</tr>
</tbody>
</table>

$f_p$ = coefficient to be taken as: $f_p = 0.28C_B + 0.01$

$\lambda$ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.45 \, L$

$k_a$ = amplitude coefficient in the longitudinal direction of the ship, to be obtained from Table 28

$k_p$ = phase coefficient to be obtained from Table 29. Intermediate values shall be interpolated.

Table 28 $k_a$ values for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>Longitudinal Position</th>
<th>$OST-1P; OST-2P$</th>
<th>$OST-1S; OST-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y ≥ 0$</td>
<td>$f_{XL} \leq 0.2$</td>
<td>$1 + [(3.5 - 2f_T) + (10f_T - 17.5)f_{XL}](1 - f_yB)$</td>
<td>$1 + (3.5 - 2f_T - 1.5f_yB)$</td>
</tr>
<tr>
<td></td>
<td>$0.2 &lt; f_{XL} \leq 0.8$</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>$f_{XL} &gt; 0.8$</td>
<td>1.0</td>
<td>$1 + 2(1 - f_T)(5f_{XL} - 4)f_yB$</td>
</tr>
</tbody>
</table>
### Table 29 $k_p$ values for OST load cases

<table>
<thead>
<tr>
<th>Transverse position</th>
<th>$f_{xL}$</th>
<th>$OST-1P - OST-2P$</th>
<th>$OST-1S - OST-2S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y &lt; 0$</td>
<td>0.0</td>
<td>1.0</td>
<td>$1 + (0.5 - f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>1.0</td>
<td>$1 + 3(0.5 - f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>$-1.0$</td>
<td>$(2.7 - 2.4f_T)f_{yB} - 1$</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>$-1.0$</td>
<td>$(2.8 - 2.6f_T)f_{yB} - 1$</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>$(f_T - 0.62)f_{yB} - 0.38$</td>
<td>$(2.38 - 3f_T)f_{yB} - 0.38$</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>$0.24 + 0.76f_{yB}$</td>
<td>$0.24 - (0.24 + f_T)f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>$-1 + 0.5f_{yB}$</td>
<td>$-1.0$</td>
</tr>
<tr>
<td>$y &gt; 0$</td>
<td>0.0</td>
<td>1 + $(0.5 - f_T)f_{yB}$</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>$1 + 3(0.5 - f_T)f_{yB}$</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>$(2.7 - 2.4f_T)f_{yB} - 1$</td>
<td>$-1.0$</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>$(2.8 - 2.6f_T)f_{yB} - 1$</td>
<td>$-1.0$</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>$(2.38 - 3f_T)f_{yB} - 0.38$</td>
<td>$(f_T - 0.62)f_{yB} - 0.38$</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>$0.24 - (0.24 + f_T)f_{yB}$</td>
<td>$0.24 + 0.76f_{yB}$</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>$-1.0$</td>
<td>$-1 + 0.5f_{yB}$</td>
</tr>
</tbody>
</table>

### 2 Loads on exposed decks

#### 2.1 Application

2.1.1 Pressures and forces on exposed decks shall only be applied for strength assessment, i.e. yield and buckling assessment.
2.1.2 The green sea pressures defined in [2.2] for exposed decks shall be considered independently of the pressures due to distributed cargo or other equipment loads and any concentrated forces due to cargo or other unit equipment loads, defined in [2.3.1] and [2.3.2] respectively.

2.2 Green sea loads

2.2.1 Pressure on exposed deck
The external dynamic pressure due to green sea loading, $P_D$, at any point of an exposed deck, in kN/m$^2$, for the static plus dynamic (S + D) design load scenarios shall be derived for each dynamic load case and shall be taken as defined in [2.2.3] to [2.2.4].

The external dynamic pressure due to green sea loading, $P_D$, at any point of an exposed deck for the static (S) design load scenarios is zero.

2.2.2 If a wave breaker is fitted on the exposed deck, no reduction in the green sea pressure is allowed for the area of the exposed deck located aft of the wave breaker.

2.2.3 HSM, HSA and FSM load cases
The external pressure, $P_D$, for HSM, HSA and FSM load cases, at any load point of an exposed deck shall be obtained, in kN/m$^2$, from the following formula, see Figure 2 and Figure 3:

$$P_D = \max (\chi P_{D-min}, P_{W,D} - \rho g (z - z_{dk})))$$

where:

- $P_{W,D} =$ pressure in kN/m$^2$ obtained at side of the exposed deck for HSM, HSA and FSM load cases as defined in [1.3]
- $P_{D-min} =$ minimum exposed freeboard deck pressure, in kN/m$^2$, to be taken as:
  - for cargo hold analysis according to Ch.7: $P_{D-min} = 0$
  - for other cases: $P_{D-min}$ as defined in Table 30
- $\chi =$ reduction factor for pressure on exposed deck above freeboard deck:
  - $\chi = \max(0.15; 0.75^C)$
  - $\chi = 1.0$ for freeboard deck
- $C = (z_{dk} - z_{fdk})/2.3$
- $z_{fdk} =$ distance from baseline to freeboard deck, in m
- $z_{dk} =$ distance from baseline to exposed deck considered at side or superstructure side, in m.

If a recess without coaming is arranged in the weather deck, $P_D$ shall be tapered linearly down to the edge of the recess, but not to be taken less than $\chi P_{D-min}$ see Figure 12. Forward and aft of the recess the pressure can be tapered linearly down to the line as shown in Figure 12. The minimum pressure $\chi P_{D-min}$ for the weather deck shall be applied to the exposed deck in way of the recess.
Figure 12 Pressure distribution, $P_D$, for HSM, HSA and FSM load cases in way of a recess at weather deck

Table 30 Minimum pressures on exposed decks for HSM, HSA, FSM load cases

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum pressure on exposed freeboard deck, $P_{D-min}$ in kN/m$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{LL} \geq 100m$</td>
</tr>
<tr>
<td>$\frac{x_{LL}}{L_{LL}} \leq 0.75$</td>
<td>34.3</td>
</tr>
<tr>
<td>$\frac{x_{LL}}{L_{LL}} &gt; 0.75$</td>
<td>$34.3 + \left[14.8 + a(L_{LL} - 100)\right]\left(4\frac{x_{LL}}{L_{LL}} - 3\right)$</td>
</tr>
</tbody>
</table>

where:
- $a$ = coefficient taken equal to:
  - $a = 0.356$ for type A, type B-60 and type B-100 freeboard ships
  - $a = 0.0726$ for type B freeboard ships
- $x_{LL}$ = X-coordinate of the load point measured from the aft end of the freeboard length $L_{LL}$.

2.2.4 BSR, BSP, OST and OSA load cases
The external pressure, $P_D$, for BSR, BSP, OST and OSA load cases at any load point of an exposed deck shall be obtained, in kN/m$^2$, by linear interpolation between the pressures at the port and starboard deck edges (see also Figure 4, [1.3.6], Figure 9 and Figure 10):

$$P_D = P_{W,D-int} - \rho g (z - z_{dk}) \text{ but not to be taken less than 0}$$

where:
- $P_{W,D-int}$ = pressure obtained by linear interpolation in transverse direction to the load point between $P_{W,D-stb}$ and $P_{W,D-pt}$
- $P_{W,D-stb}$ = pressure obtained at starboard deck edge for BSR, BSP, OST or OSA load cases as defined in [1.3], as appropriate
- $P_{W,D-pt}$ = pressure obtained at port deck edge for BSR, BSP, OST and OSA load cases as defined in [1.3], as appropriate
- $z$ = distance from baseline to load point, in m
- $z_{dk}$ = distance from baseline to exposed deck considered at side or superstructure side, in m.
If a recess without coaming is arranged in the weather deck, $P_D$ shall be tapered linearly down to 0 at the outer edge of the recess on the heeled side of the weather deck, see Figure 13. Forward and aft of the recess the pressure can be tapered linearly down to 0 at a line as shown in Figure 13.

**Figure 13 Pressure distribution, $P_D$, for BSR, BSP, OST and OSA load cases in way of a recess at weather deck**

### 2.2.5 Envelope of dynamic pressures on exposed deck

The envelope of dynamic pressure at any point of an exposed deck, $P_{D\text{-max}}$, shall be taken as the greatest pressure obtained from any of the load cases determined by [2.2.3] and [2.2.4].

### 2.3 Load carried on decks and platforms

#### 2.3.1 Pressure due to distributed load

If a distributed load is carried on a deck or platform, for example deck cargo or other equipment, the static and dynamic pressures due to this distributed load shall be considered.

The total pressure, in kN/m$^2$, due to this distributed load for the static (S) design load scenario shall be taken as:

$$P_{dl} = P_{dl-s}$$

The pressure, in kN/m$^2$, due to this distributed load for the static plus dynamic (S+D) design load scenario shall be derived for each dynamic load case and shall be taken as:

$$P_{dl} = P_{dl-s} + P_{dl-d}$$

where:

- $P_{dl-s}$ = static pressure, in kN/m$^2$, due to the distributed load, to be defined by the designer
- $P_{dl-d}$ = dynamic pressure, in kN/m$^2$, due to the distributed load
  $$= P_{dl-s} \cdot a_d/g$$
\( a_z = \) vertical envelope acceleration, in \( \text{m/s}^2 \), as defined in Sec.3 [3.3.3]. Optionally, the acceleration for the considered dynamic load case, according to Sec.3 [3.2.3], may be applied.

### 2.3.2 Concentrated force due to unit load

If a unit load, for example deck cargo, is carried on a deck or platform, the static and dynamic forces due to the unit load carried shall be considered.

The force, in kN, due to this concentrated load for the static (S) design load scenarios, shall be taken as:

\[
F_U = F_{U-s}
\]

The force, in kN, due to this concentrated load for the static plus dynamic (S + D) design load scenarios shall be derived for each dynamic load case and shall be taken as:

\[
F_U = F_{U-s} + m_U a_z
\]

where:

- \( F_{U-s} = \) static force, in kN, due to the unit load to be taken equal to: \( F_{U-s} = m_U g \)
- \( m_U = \) mass of the unit load carried, in t
- \( a_z = \) vertical envelope acceleration, in \( \text{m/s}^2 \), as defined in Sec.3 [3.3.3]. Optionally, the acceleration for the considered dynamic load case, according to Sec.3 [3.2.3], may be applied.

For heavy units with centre of gravity (COG) more than 0.25 \( b_c \) or 0.25 \( l_c \) above the deck it is attached to, where \( b_c \) and \( l_c \) are the breadth and length of the unit in m, also horizontal accelerations shall be taken into account. The longitudinal force \( F_{U-X} \), transverse force \( F_{U-Y} \) and vertical force \( F_{U-Z} \) in kN, due to this concentrated load for the static plus dynamic (S + D) design load scenarios shall be derived for each dynamic load case and shall be taken as follows:

\[
F_{U-X} = m_U a_x
\]
\[
F_{U-Y} = m_U a_y
\]
\[
F_{U-Z} = m_U a_z
\]

where:

- \( a_x = \) longitudinal acceleration, in \( \text{m/s}^2 \), at the centre of gravity of the unit load carried for the considered load case, to be obtained according to Sec.3 [3.2.1]
- \( a_y = \) transverse acceleration, in \( \text{m/s}^2 \), at the centre of gravity of the unit load carried for the considered load case, to be obtained according to Sec.3 [3.2.2]
- \( a_z = \) vertical acceleration, in \( \text{m/s}^2 \), at the centre of gravity of the unit load carried for the considered load case, to be obtained according to Sec.3 [3.2.3].

### 3 External pressures on superstructure and deckhouses

#### 3.1 Application

3.1.1 The external pressures on superstructure and deckhouses shall only be applied for strength assessment.
These pressures shall be considered as dynamic pressures and shall be applied to the appropriate structure without any static pressure load component.

3.1.2 The pressure defined in [3.4] are only applicable to the requirements given in Ch.6 Sec.8.

3.2 Exposed superstructure and deckhouse tops

3.2.1 The lateral pressure for exposed deckhouse tops, in kN/m$^2$, shall be taken according to [2.2.3].

3.3 Sides of superstructures

3.3.1 The design pressure for the external sides of superstructures, in kN/m$^2$, shall not be taken less than:

$$P_{SI} = 3C_w(C_B + 0.7) - 2(z - T_{SC})$$

but shall not be less than:

- 0 kN/m$^2$ for direct strength analysis according to Ch.7
- 2.5 kN/m$^2$ for other cases.

3.4 End bulkheads of superstructures and deckhouse walls

3.4.1 The external pressure for the aft and forward external bulkheads of superstructures and deckhouse walls, in kN/m$^2$, shall be taken as:

$$P_A = f_n f_c [f_b (z - T_{SC})]$$

but shall not be less than $P_{A-min}$.

where:

- $f_n$ = coefficient defined in Table 31
- $f_c$ = coefficient, to be taken as:

$$f_c = 0.3 + 0.7 \frac{b_1}{B_1}$$

but not less than 0.475

For exposed parts of machinery casings, $f_c$ shall not be taken less than 1.0

- $f_d$ = coefficient, to be taken as:

$$f_d = \frac{L}{160} e^{-\frac{L}{300}} - \left[ 1 - \left( \frac{L}{150} \right)^2 \right]$$

for $L < 150$ m

$$f_d = \frac{L}{160} e^{-\frac{L}{300}}$$

for $150$ m $\leq L < 300$ m

$$f_d = 11.03$$

for $L \geq 300$ m

- $b_1$ = breadth of deckhouse at the position considered
- $B_1$ = actual breadth of ship on the exposed weather deck at the position considered
- $f_b$ = coefficient defined in Table 32
\[ P_{A-min} = \text{minimum lateral pressure, in kN/m}^2, \text{ as defined in Table 33.} \]

**Table 31 Coefficient \( f_n \)**

<table>
<thead>
<tr>
<th>Type of bulkhead</th>
<th>Location</th>
<th>( f_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unprotected front bulkhead (^{1)})</td>
<td>Lowest tier (^{2)})</td>
<td>( 20 + \frac{L_2}{12} )</td>
</tr>
<tr>
<td></td>
<td>Second tier</td>
<td>( 10 + \frac{L_2}{12} )</td>
</tr>
<tr>
<td></td>
<td>Third tier and above</td>
<td>( 5 + \frac{L_2}{15} )</td>
</tr>
<tr>
<td>Protected front bulkhead (^{1)})</td>
<td>All tiers</td>
<td>( 5 + \frac{L_2}{15} )</td>
</tr>
<tr>
<td>Side bulkheads</td>
<td>All tiers</td>
<td>( 5 + \frac{L_2}{15} )</td>
</tr>
<tr>
<td>Aft end bulkheads</td>
<td>Abaft amidships</td>
<td>( 7 + \frac{L_2}{100} - 8 \frac{x}{L_2} )</td>
</tr>
<tr>
<td></td>
<td>Forward of amidships</td>
<td>( 5 + \frac{L_2}{100} - 4 \frac{x}{L_2} )</td>
</tr>
</tbody>
</table>

1) The front bulkhead of a superstructure or deckhouse may be considered as protected when it is located less than \( B_x \) behind another superstructure or deckhouse, and the width of the front bulkhead being considered is less than the width of the aft bulkhead of the superstructure or deckhouse forward of it. \( B_x \) is the local breadth of the ship at the front bulkhead.

2) The lowest tier is normally that tier which is directly situated above the uppermost continuous deck to which the moulded depth, \( D \) is measured. However, when \((D-T_{SC})\) exceeds the minimum non-corrected tabular freeboard (according to ILLC as amended) by at least one standard superstructure height (as defined in Ch.1 Sec.4 [3.3]), then this tier may be defined as the 2\(^{nd}\) tier and the tier above as the 3\(^{rd}\) tier.
Table 32 Coefficient $f_b$

<table>
<thead>
<tr>
<th>Location of bulkhead$^1$</th>
<th>$f_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{x}{L} &lt; 0.45$</td>
<td>$1 + \left( \frac{x - 0.45}{C_{B1} + 0.2} \right)^2$</td>
</tr>
<tr>
<td>$\frac{x}{L} \geq 0.45$</td>
<td>$1 + 1.5 \left( \frac{x - 0.45}{C_{B1} + 0.2} \right)^2$</td>
</tr>
</tbody>
</table>

where:

$c_{B1} = \text{block coefficient, but not less than 0.60 nor greater than 0.80. For aft deckhouse bulkheads located forward of amidships, } c_{B1} \text{ may be taken as 0.80.}$

$^1$ For deckhouse sides, the deckhouse shall be subdivided into parts of approximately equal length, not exceeding 0.15 $L$ each, and $x$ shall be taken as the $X$-coordinate of the centre of each part considered.

Table 33 Minimum lateral pressure, $P_{A-min}$

<table>
<thead>
<tr>
<th>$L$</th>
<th>Lowest tier of unprotected fronts</th>
<th>Elsewhere $^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L \leq 250$</td>
<td>$25 + \frac{L}{10}$</td>
<td>$12.5 + \frac{L}{20}$</td>
</tr>
<tr>
<td>$L &gt; 250$</td>
<td>$50$</td>
<td>$25$</td>
</tr>
</tbody>
</table>

$^1$ For the 4th tier and above, $P_{A-min}$ shall be taken equal to 12.5 kN/m$^2$ for the front bulkhead, and 2.5 kN/m$^2$ for deckhouse side and aft wall.

3.5 Windows and side scuttles

3.5.1 The design pressure $P$ on side scuttles and windows shall be taken according to Table 34.

Table 34 Design pressure for windows

<table>
<thead>
<tr>
<th>Structure</th>
<th>Design pressure [kN/m$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superstructure side</td>
<td>$\text{Max}(P_{W_1}, P_{SI})$</td>
</tr>
<tr>
<td>Deckhouse side walls</td>
<td>$P_A$</td>
</tr>
<tr>
<td>Aft wall</td>
<td></td>
</tr>
<tr>
<td>Front wall</td>
<td></td>
</tr>
</tbody>
</table>

3.5.2 The design pressure $P$ on side scuttles and windows shall be calculated as per Ch.10 Sec.1 [2] when located in a position where bow impact is applicable.

3.5.3 When windows are allowed on exposed front bulkheads on the weather deck, the design pressure according to the lowest tier shall be applied for calculation of required glass thickness.
SECTION 6 INTERNAL LOADS

Symbols

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

\[ x, y, z = X, Y \text{ and } Z \text{ coordinates, in m, of the load point with respect to the reference coordinate system defined in Sec.1 [1.2.1]} \]

\[ x_G, y_G, z_G = X, Y \text{ and } Z \text{ coordinates, in m, of the volumetric centre of gravity of the tank, considered with respect to the reference coordinate system defined in Sec.1 [1.2]} \]

\[ a_X, a_Y, a_Z = \text{longitudinal, transverse and vertical accelerations, in m/s}^2, \text{at } x_G, y_G, z_G \text{ as defined in Sec.3 [3.2]} \]

\[ \rho_L = \text{density of liquid in the tank and ballast hold, in t/m}^3, \text{normally not to be taken less than:} \]

- **for strength assessment:** \[ \rho_L = 1.025 \text{ for all liquids including oil and product cargoes. If a tank filled at 98% is intended to carry heavier liquid cargoes than 1.025 (i.e. } \rho_{\text{max-LM}} > 1.025), \text{ then } \rho_L = \rho_{\text{max-LM}} \]
- **for fatigue assessment:** \[ \rho_L = 0.9 \text{ for oil and oil product cargoes} \]
  \[ \rho_L = 1.025 \text{ for ballast tanks} \]

For the cargo tank intended to carry liquid other than oil or oil products and with a cargo density between 0.9 and 1.025 t/m\(^3\), then \( \rho_L = \rho_{\text{max-LM}} \).

The liquid cargo density for liquified gas is given in Pt.5 Ch.7.

\[ \rho_{\text{max-LM}} = \text{maximum liquid cargo density in t/m}^3, \text{associated with a full tank at 98%, from any loading condition in the ship’s loading manual or value specified by the designer} \]

\[ \rho_{\text{part}} = \text{maximum permissible high liquid cargo density, in t/m}^3, \text{associated with a partially filled cargo tank but not taken less than } \rho_L \text{ considered for strength assessment} \]

\[ \rho_{\text{slih}} = \text{liquid density, in t/m}^3, \text{to be used for sloshing assessment, taken as:} \]

- \[ \rho_{\text{slih}} = \rho_{\text{part}} \text{ for heavy liquid cargo density associated with partial filling of cargo tank} \]
- \[ \rho_{\text{slih}} = \rho_L \text{ for all other cases} \]

\[ h_{\text{max}} = \text{maximum permissible filling level, in m, taken as:} \]

- for ballast tanks: maximum tank height,
- for cargo tanks with cargo density equal to \( \rho_L \): maximum tank height
- for cargo tanks with heavy liquid cargo density equal to \( \rho_{\text{part}} \) associated with a partially filled cargo tank: \( h_{\text{part}} \) as defined in Ch.10 Sec.4 [1.2.1]

\[ f_{\text{cd}} = \text{factor for joint probability of occurrence of liquid cargo density and maximum sea state in 25 years design life, to be taken as:} \]

- \[ f_{\text{cd}} = 0.88 \text{ for strength assessment with FE analysis of cargo tanks filled with for oil or oil products cargo} \]
- \[ f_{\text{cf}} = 1.0 \text{ for other cases} \]

\[ \rho_{ST} = \text{density of steel, in t/m}^3 \]

\[ z_{\text{top}} = \text{Z coordinate of the highest point of tank, excluding small hatchways, in m} \]

\[ h_{\text{air}} = \text{height of air pipe or overflow pipe above the top of the tank, in m} \]
Part 3 Chapter 4 Section 6

**1 Pressures due to liquids**

**1.1 Total pressure**

**1.1.1 Pressures for the strength and fatigue assessments of intact conditions**

The internal pressure due to liquid acting on any load point of a tank and ballast hold boundary, in kN/m², for the static (S) design load scenarios, given in Sec.7, shall be taken as:

\[ P_{in} = P_{ls} \text{ but not less than 0} \]

The internal pressure due to liquid acting on any load point of a tank and ballast hold boundary, in kN/m², for the static plus dynamic (S+D) design load scenarios shall be derived for each dynamic load case and shall be taken as:

\[ P_{in} = P_{ls} + P_{ld} \text{ but not less than 0} \]

where:

- \( P_{ls} \) = static pressure due to liquid in tanks and ballast holds, in kN/m², as defined in [1.2.1] to [1.2.6]
- \( P_{ld} \) = dynamic inertial pressure due to liquid in tanks and ballast holds, in kN/m², as defined in [1.3].

**1.1.2 Pressures for the strength assessments of flooded conditions**

The internal pressure in flooded condition, in kN/m², acting on any load point of the watertight boundary of a hold, tank or other space for the flooded static (S) design load scenario, given in Sec.7, shall be taken as:

\[ P_{in} = P_{fs} \]

where:

- \( P_{fs} \) = static pressure of seawater due to flooding in the compartment, in kN/m², as defined in [1.2.7].

**1.2 Static liquid pressure**

**1.2.1 Normal operations at sea**

The static pressure, in kN/m², in tanks and ballast holds for normal operations at sea, shall be taken as:

\[ P_{ls} = f_{cd} \rho_L g \left( z_{top} - z \right) + P_{pv} \]

for tanks arranged with pressure relief valves

\[ P_{ls} = \rho_L g \left( z_{top} - z \right) \]

for other cases.
1.2.2 Flow through ballast water exchange
The static pressure, in kN/m$^2$, in ballast water tanks for ballast water exchange at sea, shall be taken as:

$$P_{\ell s - 2} = \rho L g (z_{top} - z + h_{drop}) + P_{drop - 1}$$

where:

$h_{drop}$ = maximum overflow height above top of the tank, in m, of flow through ballast water exchange system

$P_{drop - 1}$ = overpressure, in kN/m$^2$, during flow through ballast water exchange. $P_{drop - 1}$ shall not be taken less than 25 kN/m$^2$.

1.2.3 Normal operations at harbour/ sheltered water
The static pressure, in kN/m$^2$, due to liquid in tanks and ballast holds for normal operation at harbour/ sheltered water, shall be taken as:

$$P_{\ell s - 3} = \rho L g (z_{top} - z) + P_0$$

for cargo tanks arranged with pressure relief valves

$$P_{\ell s - 3} = \rho L g (z_{top} - z) + P_0$$

for all other cases

where:

$P_0$ = static pressure, in kN/m$^2$, to be taken as:

for tanks:

- $P_0 = 10$ for $L \leq 50$ m
- $P_0 = 0.3L - 5$ for $50$ m $< L < 100$ m
- $P_0 = 25$ for $L \geq 100$ m

for ballast hold in dry cargo vessels:

$P_0 = 0$

1.2.4 Overfilling water ballast tanks
The static pressure, in kN/m$^2$, due to ballast water overfilling, shall be taken as:

$$P_{\ell s - 4} = \rho L g (z_{top} - z + h_{air}) + P_{drop - 2}$$

where:

$P_{drop - 2}$ = overpressure in kN/m$^2$, generally taken equal to zero. If the ship is not equipped with remote soundings for the ballast system or equipped with an electronic ballast system to adjust general draft and trim condition, or other measures are provided to avoid accidental overfilling, an overpressure shall be considered but not less than 25 kN/m$^2$.

1.2.5 Tank testing
The tank testing pressure, in kN/m$^2$, shall be taken as:

$$P_{\ell s - ST} = 10(z_{ST} - z)$$
where:

\( z_{ST} = \) testing load height, in m, as defined in Table 1.

The actual tank testing shall be carried out in accordance with Pt.2 Ch.4 Sec.6.

**Table 1 Design testing load height \( z_{ST} \)**

<table>
<thead>
<tr>
<th>Compartment</th>
<th>( z_{ST} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double bottom tanks</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + h_{air} )</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{bd} )</td>
</tr>
<tr>
<td>Hopper side tanks(^1), topside tanks(^1), double side tanks(^1), fore and aft peaks used as tank, cofferdams</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + h_{air} )</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + 2.4 )</td>
</tr>
<tr>
<td>Tanks, deep tanks, fuel oil bunkers, cargo tanks(^2)</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>( z_{ST}^{3)} = z_{top} + h_{air} )</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + 2.4 )</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + 0.1 \frac{P_{PV}}{2} )</td>
</tr>
<tr>
<td>Ballast hold</td>
<td>( z_{ST} = z_{h} + 0.9 )</td>
</tr>
<tr>
<td>Chain locker</td>
<td>( z_{ST} = z_{c} )</td>
</tr>
<tr>
<td>Independent tanks</td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + h_{air} )</td>
</tr>
<tr>
<td></td>
<td>( z_{ST} = z_{top} + 0.9 )</td>
</tr>
<tr>
<td>Ballast ducts</td>
<td>Testing load height corresponding to ballast pump maximum pressure</td>
</tr>
</tbody>
</table>

where:

\( z_{bd} = Z \) coordinate, in m, of the bulkhead deck

\( z_{h} = Z \) coordinate, in m, of the top of hatch coaming

\( z_{c} = Z \) coordinate, in m, of the top of chain pipe.

1) Applicable to double bottom tank connected with hopper side tanks, topside tanks or double side tanks.

2) Tank test load is not applicable for cargo tanks carrying LNG.

3) Not applicable for cargo tanks.

**1.2.6 Static liquid pressure for the fatigue assessment**

The static pressure due to liquid in tanks and ballast holds to be used for the fatigue assessment, in kN/m\(^2\), shall be taken as:

\[
P_{fs} = \rho_{l} g (z_{top} - z)
\]

**1.2.7 Flooding**

The internal pressure in flooded condition, in kN/m\(^2\), on watertight bulkheads shall be taken as:

\[
P_{fs} = \rho g h_{fs}
\]
where:

\[ h_{fs} = \text{pressure height, in m, in flooded condition, to be taken as:} \]

\[ h_{fs} = Z_{fd} - Z; |Y| \sin \theta_{dam} + (Z_{dam} - Z) \cos \theta_{dam} \]

\[ z_{fd} = Z \text{ coordinate, in m, of the freeboard deck at side in way of the transverse section considered.} \]

\[ Z_{dam} = Z \text{ coordinate, in m, of the deepest equilibrium waterline at centre line in the damaged condition.} \]

\[ \theta_{dam} = \text{angle, in degrees, between the deepest equilibrium waterline in the damaged condition and the base line.} \]

### 1.3 Dynamic liquid pressure

1.3.1 The dynamic pressure due to liquid in tanks and ballast holds, in kN/m² shall be taken as:

\[
P_{ed} = f_{cd} \rho_h \left[ a_z z_0 (x_0 - z) + f_{ull} - \ell a_x (x_0 - x) + f_{ull} - \ell a_y (y_0 - y) \right]
\]

where:

\[ f_{ull-\ell} = \text{longitudinal acceleration correction factor for the ullage space above the liquid in tanks and ballast holds, taken as:} \]

- for strength assessment:
  - \[ f_{ull-\ell} = 0.62 \text{ for cargo tanks filled with any liquids inclusive water ballast} \]
  - \[ f_{ull-\ell} = 1.0 \text{ for other cases} \]

- for fatigue assessment:
  - \[ f_{ull-\ell} = 1.0 \text{ for other cases} \]
  - \[ f_{ull-\ell} \text{ shall not be less than 0.0 nor greater than 1.0} \]

\[ \ell_{fs} = \text{cargo tank length at the top of the tank or length of the ballast hold hatch coaming, in m} \]

\[ f_{ull-t} = \text{transverse acceleration correction factor to account for the ullage space above the liquid in tanks and ballast holds, taken as:} \]

- for strength assessment:
  - \[ f_{ull-t} = 0.67 \text{ for cargo tanks filled with any liquids inclusive water ballast} \]
  - \[ f_{ull-t} = 1.0 \text{ for other cases} \]

- for fatigue assessment:
  - \[ f_{ull-t} = 1.0 \text{ for other cases} \]

\[ b_{top} = \text{cargo tank breadth at the top of the tank or breadth of the ballast hold hatch coaming, in m} \]

\[ x_0 = X \text{ coordinate, in m, of the reference point} \]

\[ y_0 = Y \text{ coordinate, in m, of the reference point} \]

\[ z_0 = Z \text{ coordinate, in m, of the reference point}. \]
The reference point shall be taken as the point with the highest value of \( V_j \), calculated for all points that define the upper boundary of the tank or ballast hold as follows:

\[
V_j = a_x (x_j - x_G) + a_y (y_j - y_G) + (a_z + g) (z_j - z_G)
\]

where:

\( x_j \) = \( X \) coordinate, in m, of the point \( j \) on the upper boundary of the tank or ballast hold
\( y_j \) = \( Y \) coordinate, in m, of the point \( j \) on the upper boundary of the tank or ballast hold
\( z_j \) = \( Z \) coordinate, in m, of the point \( j \) on the upper boundary of the tank or ballast hold.

The following simplified method of determination of the reference point assuming a rectangular shape with area equal \( A_{\text{top}} \) of the top of the tank or the ballast hold hatch coaming is acceptable, see Figure 1:

\[
x_j = x_{\text{top}} \pm 0.5 \ell_{fs}
\]

\[
y_j = y_{\text{top}} \pm 0.5 b_{\text{top}}
\]

where

\( x_{\text{top}} \) = \( X \) coordinate, in m, of the centre of the rectangular area \( A_{\text{top}} \) at the top of the tank or the ballast hold hatch coaming
\( y_{\text{top}} \) = \( Y \) coordinate, in m, of the centre of the rectangular area \( A_{\text{top}} \) at the top of the tank or the ballast hold hatch coaming
\( A_{\text{top}} \) = \( \ell_{fs} \cdot b_{\text{top}} \): The area of an rectangular shape at the top of the tank or the ballast hold hatch coaming, in m\(^2\).

**Figure 1 Area of a rectangular shape at the top of a tank**
2 Non-exposed decks and platforms

2.1 Application

2.1.1 General
The loads on non-exposed decks including inner bottom are given in Sec.5 [2.3], except accommodation decks, wheelhouse decks and platforms in machinery space. For these decks loads defined in [2.2] and [2.3] are applicable.

2.2 Pressure due to distributed load

2.2.1 If a distributed load is carried on a deck, the static and dynamic pressures due to this distributed load shall be considered. The distributed loads shall be calculated according to Sec.5 [2.3.1].

The static distributed load $P_{dl-s}$, including selfweight, shall be defined by the designer without being less than:

- 2.5 kN/m$^2$ for accommodation decks, tween decks and platforms in general
- 3.5 kN/m$^2$ for wheelhouse deck
- 8 kN/m$^2$ for platforms in machinery space.

2.3 Concentrated force due to unit load

2.3.1 Concentrated forces on non-exposed decks shall be calculated according to Sec.5 [2.3.2].

3 Pressure for internal structures in tanks

3.1 Definition
The pressure, in kN/m$^2$, for internal structures in tanks, e.g. web of primary supporting members, shall be taken as:

$$P_{int} = 12$$
SECTION 7 DESIGN LOAD SCENARIOS

Symbols

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

\( VBM \) = design vertical bending moment, in kNm

\( M_{st} \) = design still water torsional moment in seagoing condition, in kNm, at the hull transverse section being considered, as defined in Sec.4 [2.3.1]

\( M_{sw} \) = permissible hull girder hogging and sagging still water bending moment for seagoing operation, in kNm, as defined in Sec.4 [2.2.2]

\( M_{wv-LC} \) = vertical wave bending moment for a considered dynamic load case, in kNm, as defined in Sec.4 [3.5.2]

\( HBM \) = design horizontal bending moment, in kNm

\( M_{wh-LC} \) = horizontal wave bending moment for a considered dynamic load case, in kNm, as defined in Sec.4 [3.5.4]

\( TM \) = design torsional moment, in kNm

\( M_{wt-LC} \) = wave torsional moment for a considered dynamic load case, in kNm, as defined in Sec.4 [3.5.5]

\( VSF \) = design vertical shear force, in kN

\( Q_{sw} \) = permissible hull girder positive and negative still water shear force limits for seagoing operation, in kN, as defined in Sec.4 [2.4.1] or Sec.4 [2.4.2]

\( Q_{wv-LC} \) = vertical wave shear force for a considered dynamic load case, in kN, as defined in Sec.4 [3.5.3]

\( P_{ex} \) = design external pressure, in kN/m²

\( P_{S} \) = static sea pressure at considered draught, in kN/m², as defined in Sec.5 [1.2.1]

\( P_{W} \) = dynamic pressure for a considered dynamic load case, in kN/m², as defined in Sec.5 [1.3.2] to Sec.5 [1.3.8]

\( P_{D} \) = green sea load for a considered dynamic load case, in kN/m², as defined in Sec.5 [2.2.3] and Sec.5 [2.2.4]

\( P_{in} \) = design internal pressure, in kN/m²

\( P_{int} \) = minimum pressure for internal structures in tanks as given in Sec.6 [3.1]

\( P_{ST} \) = tank testing pressure, in kN/m², see Sec.6 [1.2.5]

\( P_{es-1} \) = static tank pressure during normal operations at sea as given in Sec.6 [1.2.1]

\( P_{es-2} \) = static tank pressure during flow through ballast water exchange as given in Sec.6 [1.2.2]

\( P_{es-3} \) = static tank pressure during normal operations at harbour/sheltered water as given in Sec.6 [1.2.3]

\( P_{es-4} \) = static tank pressure during overfilling of ballast water tanks as given in Sec.6 [1.2.4]

\( P_{ld} \) = dynamic liquid pressure in tank for a considered dynamic load case, in kN/m², as defined in Sec.6 [1.3]

\( P_{bs} \) = dry bulk cargo static pressure, in kN/m², as defined in Pt.5 Ch.1 Sec.2

\( P_{bd} \) = dry bulk cargo dynamic pressure for a considered dynamic load case, in kN/m², as defined in Pt.5 Ch.1 Sec.2

\( P_{fs} \) = static pressure in compartments and tanks in flooded condition, in kN/m², as defined in Sec.6 [1.2.7]

\( P_{ds} \) = static pressure on non-exposed decks and platforms, in kN/m², as defined in Sec.6 [2.2.1]

\( P_{dt-d} \) = dynamic pressure on non-exposed decks and platforms for a considered dynamic load case, in kN/m², as defined in Sec.6 [2.2.1]

\( F_{U-S} \) = static load acting on supporting structures and securing systems for heavy units or cargo, equipment or structural components, in kN, as defined in Sec.5 [2.3.2]
1 General

1.1 Application

1.1.1 This section gives the design load scenarios that shall be used for:
— strength assessment by prescriptive and direct analysis (finite element method, FEM) methods, see [2]
— fatigue assessment by prescriptive and direct analysis (FEM) methods, see [3].

1.1.2 For the strength assessment, the principal design load scenarios consist of either S (static) loads or S + D (static + dynamic) loads. In some cases, the letter ‘A’ prefixes the S or S + D to denote that this is an accidental design load scenario. There are some additional design load scenarios to be considered which relate to impact (I) loads, sloshing (SL) loads and fatigue (F) load. Design load scenarios for impact loads (I) are given in Ch.10 Sec.1, Sec.2 and Sec.3. Design load scenarios for sloshing and liquid impact in tanks (SL) are given in Ch.10 Sec.4.

2 Design load scenarios for strength assessment

2.1 Principal design load scenarios

2.1.1 The principal design load scenarios are given in Table 1.

Table 1 Principal design load scenarios

<table>
<thead>
<tr>
<th>Load component</th>
<th>Design load scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull girder loads</td>
<td>Normal operations at harbour and sheltered water</td>
<td>Normal operation at sea</td>
<td>Flow through ballast water exchange</td>
<td>Overfilling of ballast tanks and tank testing</td>
<td>Flooding</td>
<td></td>
</tr>
<tr>
<td>VBM</td>
<td>Static (S)</td>
<td>Static + dynamic (S+D)</td>
<td>Static + dynamic (S+D)</td>
<td>Static (S) and (T)</td>
<td>Static (S)</td>
<td></td>
</tr>
<tr>
<td>HBM</td>
<td>-</td>
<td>M_{sw} + M_{wv-LC}</td>
<td>M_{sw} + M_{wv-LC}</td>
<td>M_{sw}</td>
<td>M_{sw}</td>
<td></td>
</tr>
<tr>
<td>VSF</td>
<td>Q_{sw}</td>
<td>Q_{sw} + Q_{wv-LC}</td>
<td>Q_{sw} + Q_{wv-LC}</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>TM</td>
<td>M_{st}</td>
<td>M_{st} + M_{wt-LC}</td>
<td>M_{st} + M_{wt-LC}</td>
<td>M_{st}</td>
<td>M_{st}</td>
<td></td>
</tr>
</tbody>
</table>
### 3 Design load scenarios for fatigue assessment

#### 3.1 Design load scenarios

3.1.1 The design load scenarios for fatigue assessment are given in Table 2.

<table>
<thead>
<tr>
<th>Local loads</th>
<th>Design load scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{ex}$</td>
<td>1</td>
</tr>
<tr>
<td>Exposed decks</td>
<td>-</td>
</tr>
<tr>
<td>External shell</td>
<td>$P_S$</td>
</tr>
<tr>
<td>Superstructure sides</td>
<td>-</td>
</tr>
<tr>
<td>Superstructure end bulkheads and deckhouse walls</td>
<td>-</td>
</tr>
<tr>
<td>Boundaries of water ballast tanks $^1$</td>
<td>$P_{bs}$</td>
</tr>
<tr>
<td>Boundaries of tanks other than water ballast tanks</td>
<td>-</td>
</tr>
<tr>
<td>Watertight boundaries</td>
<td>-</td>
</tr>
<tr>
<td>Boundaries of bulk cargo holds</td>
<td>$P_{bs}$</td>
</tr>
<tr>
<td>Internal structures in tanks</td>
<td>$P_{int}$</td>
</tr>
<tr>
<td>$P_{dt}$</td>
<td>Exposed decks and non-exposed decks and platforms</td>
</tr>
<tr>
<td>$F_U$</td>
<td>Heavy units on internal and external decks</td>
</tr>
<tr>
<td>$P_{wl}$</td>
<td>Decks and hatch covers/RoRo equipment</td>
</tr>
</tbody>
</table>

1) WB cargo hold is considered as ballast tank except for design load scenario ‘ballast water exchange’.
2) Hull girder torsion to be considered for ships with large deck openings only.
<table>
<thead>
<tr>
<th>Load component</th>
<th>Design load scenario</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull girder loads</td>
<td>Static + dynamic (F: S+D)</td>
<td></td>
</tr>
<tr>
<td>VBM</td>
<td>$M_{SW} + M_{WV-LC}$</td>
<td></td>
</tr>
<tr>
<td>HBM</td>
<td>$M_{WH-LC}$</td>
<td></td>
</tr>
<tr>
<td>VSF</td>
<td>$Q_{SW} + Q_{WV-LC}$</td>
<td></td>
</tr>
<tr>
<td>$TM^{2)}$</td>
<td>$M_{WT-LC}$</td>
<td></td>
</tr>
<tr>
<td>Local loads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ex}$</td>
<td>Exposed decks</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>External shell</td>
<td>$P_{S} + P_{W}$</td>
</tr>
<tr>
<td>$P_{in}$</td>
<td>Boundaries of water ballast tanks $^{1)}$</td>
<td>$P_{bs} + P_{bd}$</td>
</tr>
<tr>
<td></td>
<td>Boundaries of tanks other than water ballast tanks</td>
<td>$P_{bs} + P_{bd}$</td>
</tr>
<tr>
<td></td>
<td>Watertight bulkheads</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Boundaries of bulk cargo holds</td>
<td>-</td>
</tr>
<tr>
<td>$P_{el}$</td>
<td>Exposed decks and non-exposed decks and platforms</td>
<td>-</td>
</tr>
<tr>
<td>$F_{U}$</td>
<td>Heavy units on internal and external decks</td>
<td>-</td>
</tr>
</tbody>
</table>

1) WB cargo hold is considered as ballast tank except for design load scenario ‘ballast water exchange at sea’.
2) Hull girder torsion to be considered for ships with large deck openings only.
SECTION 8 LOADING CONDITIONS

1 Standard design loading conditions

1.1 Seagoing design loading conditions

1.1.1 Design loading conditions as specified in Ch.15 Sec.1 [4.3] shall be provided as design basis in addition to, if applicable, design load conditions required by Pt.5 or related to the vessel’s particular operation. All the above design loading conditions shall be evaluated for at least departure and arrival conditions. The departure conditions shall be based on bunker tanks not taken less than 95% full and other consumables taken at 100% capacity. The arrival conditions shall be based on bunker tanks not taken more than 10% full and other consumables taken at 100% capacity.

1.1.2 The design cargo and ballast loading conditions, based on the amount of bunker, fresh water and stores at departure and arrival, shall be considered for the still water bending moment and shear force calculations. Where the amount and disposition of consumables and cargo at any intermediate stage of the voyage are considered more severe, calculations for such intermediate conditions shall be submitted in addition to those for departure and arrival conditions. Also, where any ballasting and/or de-ballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or de-ballasting shall be submitted and included in the loading manual.

1.1.3 Conditions covering procedures for sequential ballast water exchange, if applicable, shall be included in the loading manual.

1.2 Partially filled ballast tanks in seagoing design loading condition

1.2.1 Partially filled ballast tanks in ballast loading condition
Ballast loading conditions involving partially filled peak and/or other ballast tanks at departure, arrival or during intermediate conditions are not permitted to be used as design loading conditions unless design stress limits are satisfied for all filling levels between empty and full. To demonstrate the strength compliance with all filling levels between empty and full, it will be acceptable if the still water bending moment, shear force and torsional moment, if applicable, are calculated and shown within the relevant permissible limits. These values shall be obtained for each condition at departure, arrival and any intermediate condition as required by [1.1.2], with the tanks intended to be partially filled assumed to be:
— empty
— full
— partially filled at intended level.
Where multiple tanks are intended to be partially filled, all combinations of empty, full or partially filled at intended level for those tanks shall be investigated.

1.2.2 Partially filled ballast tanks in cargo loading condition
In cargo loading conditions, the requirement in [1.2.1] applies to peak ballast tanks only.

1.2.3 Partially filled ballast tanks in ballast water exchange condition
The requirements [1.2.1] and [1.2.2] are not applicable to ballast water exchange conditions.
2 Loading conditions for primary supporting members

2.1 General

2.1.1 Loading conditions for evaluation of primary supporting members shall envelop the most critical loading combinations the ship can be subject to when operated in accordance with loading guidance information.

2.1.2 The loading conditions shall be defined with consideration to:

— all intact loading conditions in loading manual
— operational limitations in loading guidance information
— the ship arrangement and possible combination of local loading and global loading draught of empty hold and hull girder.

Reference is made to Pt.5 for standard loading conditions for different ship types.
CHANGES – HISTORIC

July 2016 edition

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

• Sec.4 Hull girder loads
  — Sec.4 [2.3]: The stillwater torsional moment is modified.

• Sec.5 External loads
  — Sec.5 [1.3.5]: A correction factor is inserted for $P_{BSR}$
  — Sec.5 [1.3.7]: A correction factor is inserted for $P_{OST}$
  — Sec.5 [2.3.1]: The definition of dynamic pressure due to distributed load, $P_{dl-d}$, is added.
  — Sec.5 [2.3.2]: The formulas for concentrated dynamic force are corrected, the factor $f_{\beta}$ is removed.

October 2015 edition

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

Amendments January 2016

• Sec.3 Longitudinal envelope accelerations
  — [3.3.1]: Modified formula

• Sec.4 Stillwater bending moment
  — [2.2.1]: Clarification

• Sec.5 External loads
  — [1.3.8]: Modified formula for OSA
  — [2.2.3]: Error correction
  — [2.2.4]: Error correction
  — [3.3.1]: Modified formula for PSI
  — Table 33: Modified Pa
  — Table 34: New table clarifying pressure for windows

• Sec.7 - Design load scenarios
  — Table 1: Added wheel load for clarity
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