RULES FOR CLASSIFICATION

Ships

Edition July 2019

Part 3 Hull

Chapter 4 Loads

DNV GL AS

FOREWORD

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

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

This document supersedes the July 2018 edition of DNVGL-RU-SHIP Pt.3 Ch.4.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or subsection, normally only the title will be in red colour.

Changes July 2019, entering into force 1 January 2020

Topic	*Reference*	*Description*
Clarification of rules	Sec.4 [2.3.1]	The application of design minimum still water torsional moment at any longitudinal position has been clarified. In addition has the still water torsional moment for global finite element analysis been clarified.
Loads on superstructure and deckhouses	Sec.5 [2.2.3] and Sec.5 [2.3.1]	In Sec.5 [2.2.3] finite element analysis is included, and the reference is updated. In Sec.5 [2.3.1] the minimum static design load is added.
	Sec.5 [3.3.1]	The design pressure for the external sides of superstructure is updated.
	Sec.5 [3.4.1]	A guidance note regarding longitudinal deckhouse walls is added.

Editorial corrections

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

CONTENTS

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).

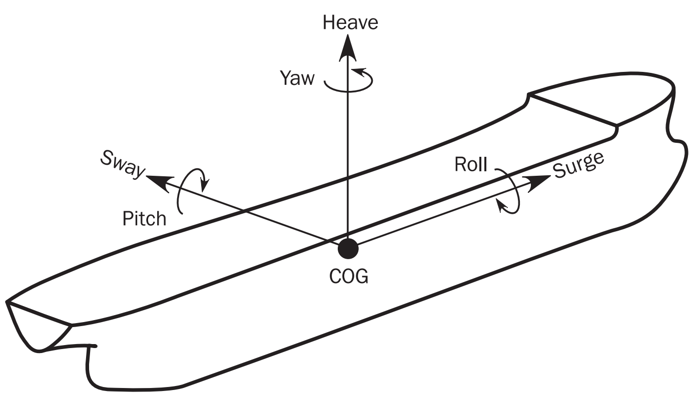


Figure 1 Definition of positive motions

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} and 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.

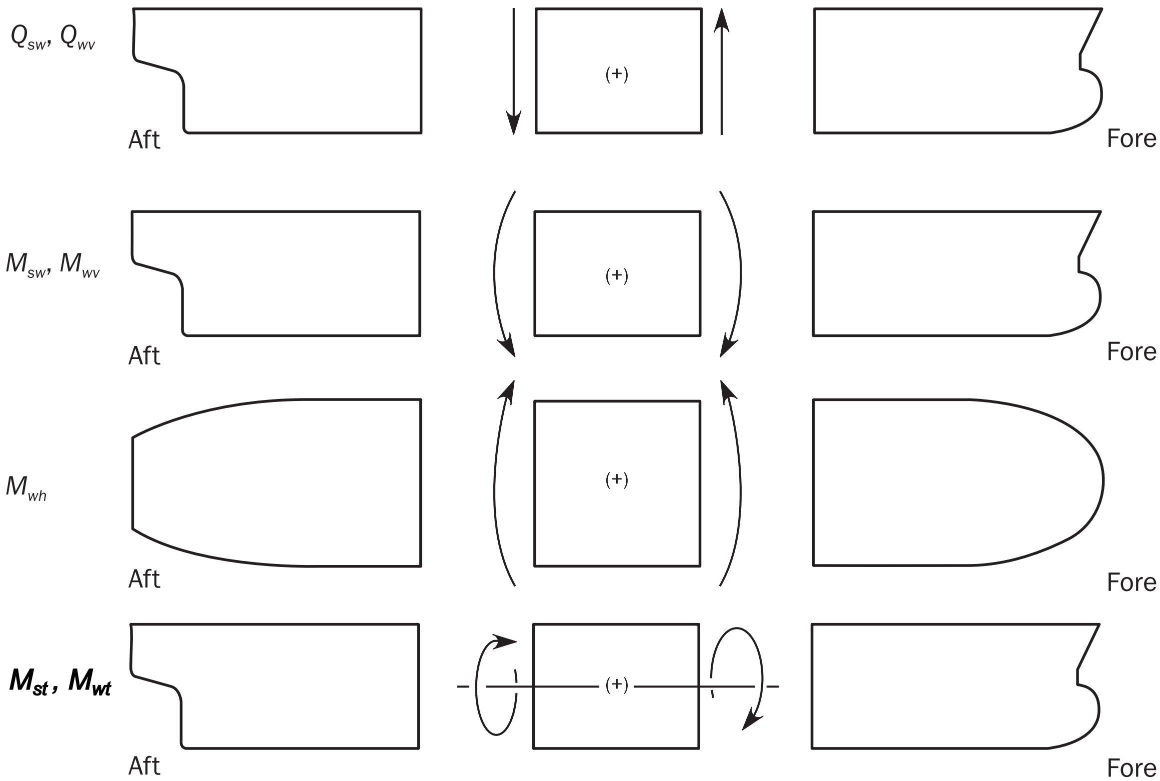


Figure 2 Sign conventions for shear forces Q_{sw}, Q_{wv} and bending moments M_{sw}, M_{wv}, M_{wh}, M_{st} and M_{wt}

SECTION 2 DYNAMIC LOAD CASES

Symbols

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

a_{surge}, $a_{pitch\text{-}x}$, a_{sway}, $a_{roll\text{-}y}$, a_{heave}, $a_{roll\text{-}z}$, $a_{pitch\text{-}z}$ = acceleration components, as defined in Sec.3

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

$f_{xL} = \frac{x}{L}$, 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

$f_{\ell p}$ = factor depending on longitudinal position along the ship, to be taken as:

$f_{\ell p} = 1.0$ for $x/L \leq 0.5$

$f_{\ell p} = -1.0$ for $0.5 < x/L$

$f_{\ell p\text{-}OST}$ = factor for the longitudinal distribution of the torsional moment for the OST load case, as defined in Sec.4 [3.4]

$f_{\ell p\text{-}OSA}$ = 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

θ = roll angle, in deg, as defined in Sec.3 [2.1.1]

φ = 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 EDW 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

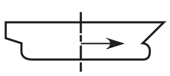
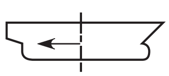
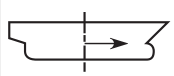
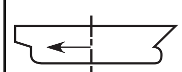
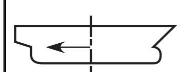
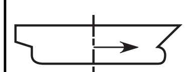
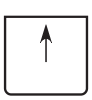
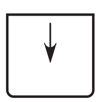
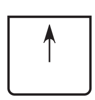
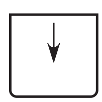
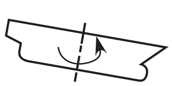
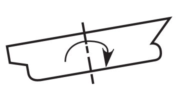
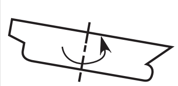
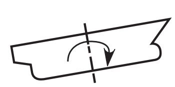
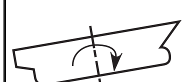
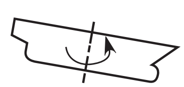
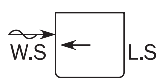
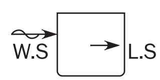
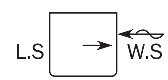
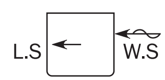
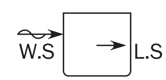
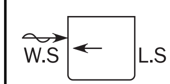
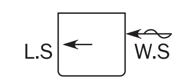
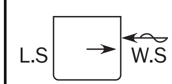
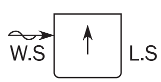
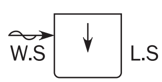
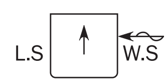
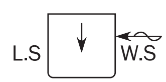
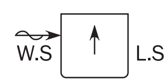
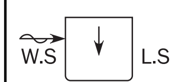
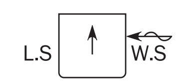
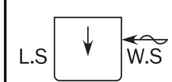
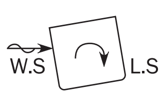
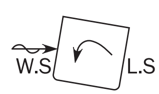
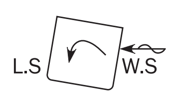
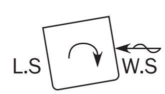
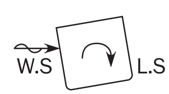
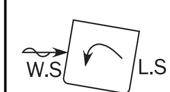
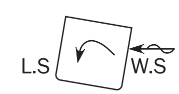
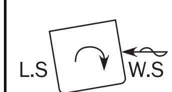
Load case	*HSM-1*	*HSM-2*	*HSA-1*	*HSA-2*	*FSM-1*	*FSM-2*
EDW	HSM		HSA		FSM	
Heading	Head		Head		Following	
Effect	Max. bending moment		Max. vertical acceleration		Max. bending moment	
VWBM	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore
HWBM	-	-	-	-	-	-
TM	-	-	-	-	-	-
Surge	To stern	To bow	To stern	To bow	To bow	To stern
a_{surge}						
Sway	-	-	-	-	-	-
a_{sway}	-	-	-	-	-	-
Heave	Down	Up	Down	Up	-	-
a_{heave}					-	-
Roll	-	-	-	-	-	-
a_{roll}	-	-	-	-	-	-
Pitch	Bow down	Bow up	Bow down	Bow up	Bow up	Bow down
a_{pitch}						

Table 2 Ship responses for BSR and BSP load cases - strength assessment

Load case	*BSR-1P*	*BSR-2P*	*BSR-1S*	*BSR-2S*	*BSP-1P*	*BSP-2P*	*BSP-1S*	*BSP-2S*
EDW	BSR		BSR		BSP		BSP	
Heading	Beam				Beam			
Effect	Max. roll				Max. pressure at waterline			
VWBM	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore
HWBM	Stbd tensile	Port tensile	Port tensile	Stbd tensile	Stbd tensile	Port tensile	Port tensile	Stbd tensile
TM	-	-	-	-	-	-	-	-
Surge	-	-	-	-	-	-	-	-
a_{surge}	-	-	-	-	-	-	-	-
Sway	To starboard	To portside	To portside	To starboard	To portside	To starboard	To starboard	To portside
a_{sway}								
Heave	Down	Up	Down	Up	Down	Up	Down	Up
a_{heave}								
Roll	Portside down	Portside up	Starboard down	Starboard up	Portside down	Portside up	Starboard down	Starboard up
a_{roll}								
Pitch	-	-	-	-	Bow down	Bow up	Bow down	Bow up

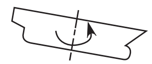
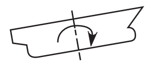
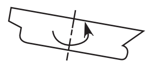
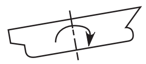
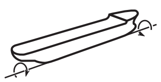
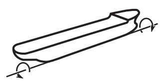
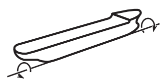
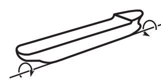
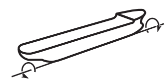
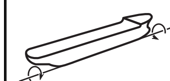
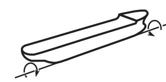
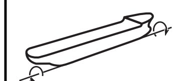
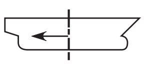
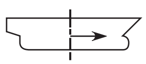
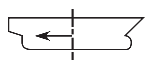
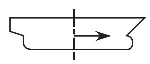
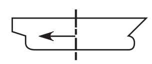
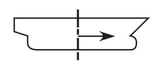
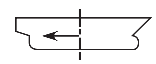
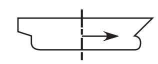
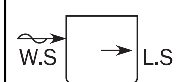
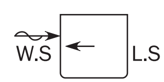
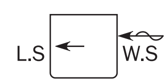
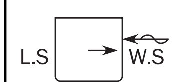
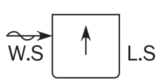
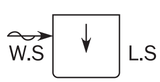
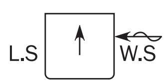
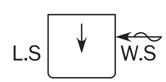
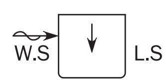
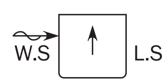
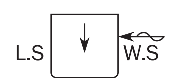
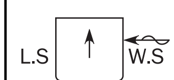
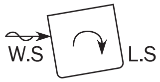
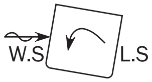
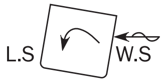
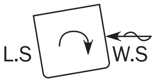
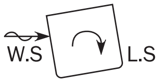
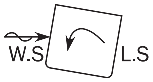
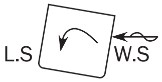
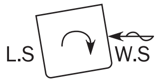
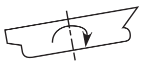
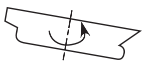
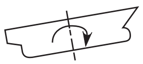
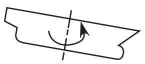
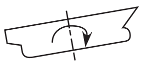
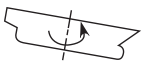
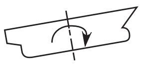
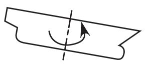
Load case	*BSR-1P*	*BSR-2P*	*BSR-1S*	*BSR-2S*	*BSP-1P*	*BSP-2P*	*BSP-1S*	*BSP-2S*
a_{pitch}	-	-	-	-				

Table 3 Ship responses for OST and OSA load cases - strength assessment

Load case	*OST-1P*	*OST-2P*	*OST-1S*	*OST-2S*	*OSA-1P*	*OSA-2P*	*OSA-1S*	*OSA-2S*
EDW	OST				OSA			
Heading	Oblique				Oblique			
Effect	Max. torsional moment				Max. pitch acceleration			
VWBM	Sagging	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Sagging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore
HWBM	Port tensile	Stbd tensile	Stbd tensile	Port tensile	Stbd tensile	Port tensile	Port tensile	Stbd tensile
TM								
Surge	To bow	To stern	To bow	To stern	To bow	To stern	To bow	To stern
a_{surge}								
Sway	-	-	-	-	To portside	To starboard	To starboard	To portside
a_{sway}	-	-	-	-				
Heave	Down	Up	Down	Up	Up	Down	Up	Down
a_{heave}								
Roll	Portside down	Portside up	Starboard down	Starboard up	Portside down	Portside up	Starboard down	Starboard up

Load case	*OST-1P*	*OST-2P*	*OST-1S*	*OST-2S*	*OSA-1P*	*OSA-2P*	*OSA-1S*	*OSA-2S*
a_{roll}								
Pitch	Bow up	Bow down	Bow up	Bow down	Bow up	Bow down	Bow up	Bow down
a_{pitch}								

2.2 Load combination factors

2.2.1 The load combinations 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

Load component		*LCF*	*HSM-1*	*HSM-2*	*HSA-1*	*HSA-2*	*FSM-1*	*FSM-2*
Hull girder loads	M_{WV}	C_{WV}	−1	1	−0.7	0.7	$-0.4f_T - 0.6$	$0.4f_T + 0.6$
	Q_{WV}	C_{QW}	$-1.0f_{\ell p}$	$1.0f_{\ell p}$	$-0.6f_{\ell p}$	$0.6f_{\ell p}$	$-1.0f_{\ell p}$	$1.0f_{\ell p}$
	M_{WH}	C_{WH}	0	0	0	0	0	0
	M_{WT}	C_{WT}	0	0	0	0	0	0
Longitudinal accelerations	a_{surge}	C_{XS}	$0.6 - 0.2f_T$	$0.2f_T - 0.6$	0.2	−0.2	$0.2 - 0.4f_T$	$0.4f_T - 0.2$
	$a_{pitch\text{-}x}$	C_{XP}	$-0.15\text{-}L_1/300$	$0.15+L_1/300$	−1.0	1.0	0.15	−0.15
	$g\ \sin\varphi$	C_{XG}	0.6	−0.6	$0.4f_T + 0.1$	$-0.4f_T - 0.1$	−0.2	0.2
Transverse accelerations	a_{sway}	C_{YS}	0	0	0	0	0	0
	$a_{roll\text{-}y}$	C_{YR}	0	0	0	0	0	0
	$g\ \sin\theta$	C_{YG}	0	0	0	0	0	0
Vertical accelerations	a_{heave}	C_{ZH}	$0.5f_T - 0.15$	$0.15 - 0.5f_T$	0.4	−0.4	0	0
	$a_{roll\text{-}z}$	C_{ZR}	0	0	0	0	0	0
	$a_{pitch\text{-}z}$	C_{ZP}	−0.7	0.7	−1.0	1.0	0.15	−0.15

Table 5 Load combination factors for BSR and BSP load cases - strength assessment

Load component		*LCF*	*BSR-1P*	*BSR-2P*	*BSR-1S*	*BSR-2S*	*BSP-1P*	*BSP-2P*	*BSP-1S*	*BSP-2S*
Hull girder loads	M_{WV}	C_{WV}	$0.1 - 0.2f_T$	$0.2f_T - 0.1$	$0.1 - 0.2f_T$	$0.2f_T - 0.1$	$0.3 - 0.8f_T$	$0.8f_T - 0.3$	$0.3 - 0.8f_T$	$0.8f_T - 0.3$
	Q_{WV}	C_{QW}	$(0.1 - 0.2f_T)\ f_{\ell p}$	$(0.2f_T - 0.1)\ f_{\ell p}$	$(0.1 - 0.2f_T)\ f_{\ell p}$	$(0.2f_T - 0.1)\ f_{\ell p}$	$(0.3 - 0.8f_T)\ f_{\ell p}$	$(0.8f_T - 0.3)\ f_{\ell p}$	$(0.3 - 0.8f_T)\ f_{\ell p}$	$(0.8f_T - 0.3)\ f_{\ell p}$
	M_{WH}	C_{WH}	$1.2 - 1.1f_T$	$1.1f_T - 1.2$	$1.1f_T - 1.2$	$1.2 - 1.1f_T$	$0.7 - 0.7f_T$	$0.7f_T - 0.7$	$0.7f_T - 0.7$	$0.7 - 0.7f_T$
	M_{WT}	C_{WT}	0	0	0	0	0	0	0	0
Longitudinal accelerations	a_{surge}	C_{XS}	0	0	0	0	0	0	0	0
	$a_{pitch\text{-}x}$	C_{XP}	0	0	0	0	$0.1 - 0.3f_T$	$0.3f_T - 0.1$	$0.1 - 0.3f_T$	$0.3f_T - 0.1$
	$g\sin\varphi$	C_{XG}	0	0	0	0	$0.3f_T - 0.1$	$0.1 - 0.3f_T$	$0.3f_T - 0.1$	$0.1 - 0.3f_T$
Transverse accelerations	a_{sway}	C_{YS}	$0.2 - 0.2f_T$	$0.2f_T - 0.2$	$0.2f_T - 0.2$	$0.2 - 0.2f_T$	−0.9	0.9	0.9	−0.9
	$a_{roll\text{-}y}$	C_{YR}	1	−1	−1	1	0.3	−0.3	−0.3	0.3
	$g\sin\theta$	C_{YG}	−1	1	1	−1	−0.2	0.2	0.2	−0.2
Vertical accelerations	a_{heave}	C_{ZH}	$0.7 - 0.4f_T$	$0.4f_T - 0.7$	$0.7 - 0.4f_T$	$0.4f_T - 0.7$	1	−1	1	−1
	$a_{roll\text{-}z}$	C_{ZR}	1	−1	−1	1	0.3	−0.3	−0.3	0.3
	$a_{pitch\text{-}z}$	C_{ZP}	0	0	0	0	$0.1 - 0.3f_T$	$0.3f_T - 0.1$	$0.1 - 0.3f_T$	$0.3f_T - 0.1$

Table 6 Load combination factors for OST and OSA load cases - strength assessment

Load component		*LCF*	*OST-1P*	*OST-2P*	*OST-1S*	*OST-2S*	*OSA-1P*	*OSA-2P*	*OSA-1S*	*OSA-2S*
Hull girder loads	M_{WV}	C_{WV}	$-0.3 - 0.2f_T$	$0.3 + 0.2f_T$	$-0.3 - 0.2f_T$	$0.3 + 0.2f_T$	$0.75 - 0.5f_T$	$-0.75 + 0.5f_T$	$0.75 - 0.5f_T$	$-0.75 + 0.5f_T$
	Q_{WV}	C_{QW}	$(-0.35 - 0.2f_T)\ f_{\ell p}$	$(0.35 + 0.2f_T)\ f_{\ell p}$	$(-0.35 - 0.2f_T)\ f_{\ell p}$	$(0.35 + 0.2f_T)\ f_{\ell p}$	$(0.6 - 0.4f_T)\ f_{\ell p}$	$(-0.6 + 0.4f_T)\ f_{\ell p}$	$(0.6 - 0.4f_T)\ f_{\ell p}$	$(-0.6 + 0.4f_T)\ f_{\ell p}$
	M_{WH}	C_{WH}	-1.0	1.0	1.0	-1.0	$0.55 + 0.2f_T$	$-0.55 - 0.2f_T$	$-0.55 - 0.2f_T$	$0.55 + 0.2f_T$
	M_{WT}	C_{WT}	$-f_{\ell p\text{-}OST}$	$f_{\ell_p\text{-}OST}$	$f_{\ell_p\text{-}OST}$	$-f_{\ell_p\text{-}OST}$	$-f_{\ell_p\text{-}OSA}$	$f_{\ell_p\text{-}OSA}$	$f_{\ell_p\text{-}OSA}$	$-f_{\ell_p\text{-}OSA}$
Longitudinal accelerations	a_{surge}	C_{XS}	$0.1f_T - 0.15$	$0.15 - 0.1f_T$	$0.1f_T - 0.15$	$0.15 - 0.1f_T$	-0.45	0.45	-0.45	0.45
	$a_{pitch\text{-}x}$	C_{XP}	$0.7 - 0.3f_T$	$0.3f_T - 0.7$	$0.7 - 0.3f_T$	$0.3f_T - 0.7$	0.5	-0.5	0.5	-0.5
	$g\sin\varphi$	C_{XG}	$0.2f_T - 0.45$	$0.45 - 0.2f_T$	$0.2f_T - 0.45$	$0.45 - 0.2f_T$	-0.8	0.8	-0.8	0.8
Transverse accelerations	a_{sway}	C_{YS}	0	0	0	0	$-0.2 - 0.1f_T$	$0.2 + 0.1f_T$	$0.2 + 0.1f_T$	$-0.2 - 0.1f_T$
	$a_{roll\text{-}y}$	C_{YR}	$0.4f_T - 0.25$	$0.25 - 0.4f_T$	$0.25 - 0.4f_T$	$0.4f_T - 0.25$	$0.3 - 0.2f_T$	$0.2f_T - 0.3$	$0.2f_T - 0.3$	$0.3 - 0.2f_T$
	$g\sin\theta$	C_{YG}	$0.1 - 0.2f_T$	$0.2f_T - 0.1$	$0.2f_T - 0.1$	$0.1 - 0.2f_T$	$0.1f_T - 0.2$	$0.2 - 0.1f_T$	$0.2 - 0.1f_T$	$0.1f_T - 0.2$
Vertical accelerations	a_{heave}	C_{ZH}	$0.2f_T - 0.05$	$0.05 - 0.2f_T$	$0.2f_T - 0.05$	$0.05 - 0.2f_T$	$-0.2f_T$	$0.2f_T$	$-0.2f_T$	$0.2f_T$
	$a_{roll\text{-}z}$	C_{ZR}	$0.4f_T - 0.25$	$0.25 - 0.4f_T$	$0.25 - 0.4f_T$	$0.4f_T - 0.25$	$0.3 - 0.2f_T$	$0.2f_T - 0.3$	$0.2f_T - 0.3$	$0.3 - 0.2f_T$
	$a_{pitch\text{-}z}$	C_{ZP}	$0.7 - 0.3f_T$	$0.3f_T - 0.7$	$0.7 - 0.3f_T$	$0.3f_T - 0.7$	1.0	-1.0	1.0	-1.0

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

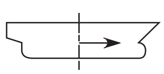
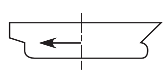
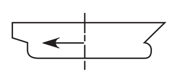
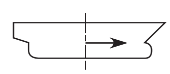
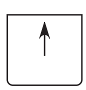
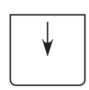
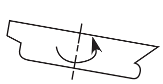
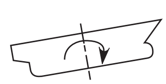
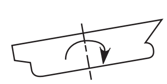
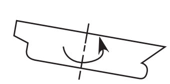
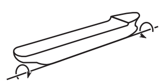
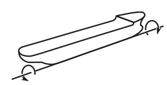
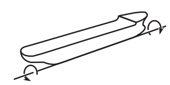
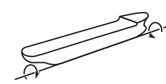
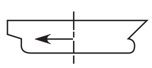
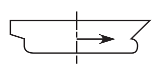
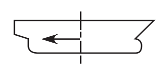
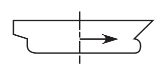
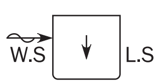
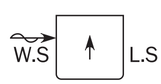
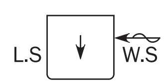
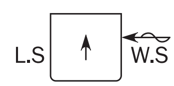
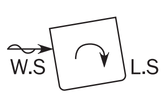
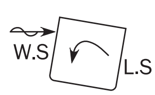
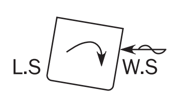
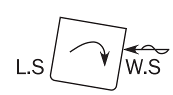
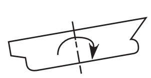
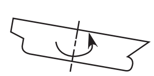
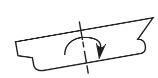
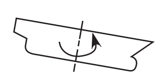
Load case	*HSM-1*	*HSM-2*	*FSM-1*	*FSM-2*
EDW	HSM		FSM	
Heading	Head		Following	
Effect	Max. bending moment		Max. bending moment	
VWBM	Sagging	Hogging	Sagging	Hogging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore
HWBM	-	-	-	-
TM	-	-	-	-
Surge	To stern	To bow	To bow	To stern
a_{surge}				
Sway	-	-	-	-
a_{sway}	-	-	-	-
Heave	Down	Up	-	-
a_{heave}			-	-
Roll	-	-	-	-
a_{roll}	-	-	-	-
Pitch	Bow down	Bow up	Bow up	Bow down
a_{pitch}				

Table 8 Ship responses for BSR and BSP load cases - fatigue assessment

Load case	*BSR-1P*	*BSR-2P*	*BSR-1S*	*BSR-2S*	*BSP-1P*	*BSP-2P*	*BSP-1S*	*BSP-2S*
EDW	BSR		BSR		BSP		BSP	
Heading	Beam				Beam			
Effect	Max. roll				Max. pressure at waterline			
VWBM	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging	Sagging	Hogging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore
HWBM	Stbd tensile	Port tensile	Port tensile	Stbd tensile	Stbd tensile	Port tensile	Port tensile	Stbd tensile
TM	-	-	-	-	-	-	-	-
Surge	-	-	-	-	-	-	-	-
a_{surge}	-	-	-	-	-	-	-	-
Sway	To starboard	To portside	To portside	To starboard	To portside	To starboard	To starboard	To portside
a_{sway}	W.S ← L.S	W.S → L.S	L.S → W.S	L.S ← W.S	W.S → L.S	W.S ← L.S	L.S ← W.S	L.S → W.S
Heave	Down	Up	Down	Up	Down	Up	Down	Up
a_{heave}	W.S ↑ L.S	W.S ↓ L.S	L.S ↑ W.S	L.S ↓ W.S	W.S ↑ L.S	W.S ↓ L.S	L.S ↑ W.S	L.S ↓ W.S
Roll	Portside down	Portside up	Starboard down	Starboard up	Portside down	Portside up	Starboard down	Starboard up
a_{roll}	W.S ↻ L.S	W.S ↺ L.S	L.S ↺ W.S	L.S ↻ W.S	W.S ↻ L.S	W.S ↺ L.S	L.S ↺ W.S	L.S ↻ W.S
Pitch	-	-	-	-	-	-	-	-
a_{pitch}	-	-	-	-	-	-	-	-

Table 9 Ship responses for OST load cases - fatigue assessment

Load case	*OST-1P*	*OST-2P*	*OST-1S*	*OST-2S*
EDW	OST			
Heading	Oblique			
Effect	Max. torsional moment			
VWBM	Sagging	Hogging	Sagging	Hogging
VWSF	Negative–aft Positive–fore	Positive–aft Negative–fore	Negative–aft Positive–fore	Positive–aft Negative–fore
HWBM	Port tensile	Stbd tensile	Stbd tensile	Port tensile
TM				
Surge	To bow	To stern	To bow	To stern
a_{surge}				
Sway	-	-	-	-
a_{sway}	-	-	-	-
Heave	Up	Down	Up	Down
a_{heave}				
Roll	Portside down	Portside up	Starboard down	Starboard up
a_{roll}				
Pitch	Bow up	Bow down	Bow up	Bow down
a_{pitch}				

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

Load component		*LCF*	*HSM-1*	*HSM-2*	*FSM-1*	*FSM-2*
Hull girderloads	M_{WV}	C_{WV}	−1	1	$-0.75 - 0.2f_T$	$0.75 + 0.2f_T$
	Q_{WV}	C_{QW}	$-1.0\ f_{\ell p}$	$1.0\ f_{\ell p}$	$(-0.75 - 0.2f_T)\ f_{\ell p}$	$(0.75 + 0.2f_T)\ f_{\ell p}$
	M_{WH}	C_{WH}	0	0	0	0
	M_{WT}	C_{WT}	0	0	0	0
Longitudinal accelerations	a_{surge}	C_{XS}	$0.3 - 0.2f_T$	$0.2f_T - 0.3$	$-0.4f_T + 0.2$	$0.4f_T - 0.2$
	$a_{pitch\text{-}x}$	C_{XP}	−0.6	0.6	0.1	−0.1
	$g\ sin\varphi$	C_{XG}	$0.4f_T + 0.4$	$-0.4f_T - 0.4$	−0.15	0.15
Transverse accelerations	a_{sway}	C_{YS}	0	0	0	0
	$a_{roll\text{-}y}$	C_{YR}	0	0	0	0
	$g\ sin\theta$	C_{YG}	0	0	0	0
Vertical accelerations	a_{heave}	C_{ZH}	$0.8f_T - 0.15$	$0.15 - 0.8f_T$	0	0
	$a_{roll\text{-}z}$	C_{ZR}	0	0	0	0
	$a_{pitch\text{-}z}$	C_{ZP}	−0.6	0.6	0.1	−0.1

Table 11 Load combination factors for BSR and BSP load cases - fatigue assessment

Load component		*LCF*	*BSR-1P*	*BSR-2P*	*BSR-1S*	*BSR-2S*	*BSP-1P*	*BSP-2P*	*BSP-1S*	*BSP-2S*
Hull girder loads	M_{WV}	C_{WV}	$0.1 - 0.2f_T$	$0.2f_T - 0.1$	$0.1 - 0.2f_T$	$0.2f_T - 0.1$	$0.3 - 0.8f_T$	$0.8f_T - 0.3$	$0.3 - 0.8f_T$	$0.8f_T - 0.3$
	Q_{WV}	C_{QW}	$(0.1 - 0.2f_T)\ f_{\ell p}$	$(0.2f_T - 0.1)\ f_{\ell p}$	$(0.1 - 0.2f_T)\ f_{\ell p}$	$(0.2f_T - 0.1)\ f_{\ell p}$	$(0.3 - 0.8f_T)\ f_{\ell p}$	$(0.8f_T - 0.3)\ f_{\ell p}$	$(0.3 - 0.8f_T)\ f_{\ell p}$	$(0.8f_T - 0.3)\ f_{\ell p}$
	M_{WH}	C_{WH}	$1.1 - f_T$	$f_T - 1.1$	$f_T - 1.1$	$1.1 - f_T$	$0.6 - 0.6f_T$	$0.6f_T - 0.6$	$0.6f_T - 0.6$	$0.6 - 0.6f_T$
	M_{WT}	C_{WT}	0	0	0	0	0	0	0	0
Longitudinal accelerations	a_{surge}	C_{XS}	0	0	0	0	0	0	0	0
	$a_{pitch-x}$	C_{XP}	0	0	0	0	0	0	0	0
	$g\ sin\varphi$	C_{XG}	0	0	0	0	0	0	0	0
Transverse accelerations	a_{sway}	C_{YS}	$0.2 - 0.2f_T$	$0.2f_T - 0.2$	$0.2f_T - 0.2$	$0.2 - 0.2f_T$	−0.95	0.95	0.95	−0.95
	a_{roll-y}	C_{YR}	1	−1	−1	1	0.3	−0.3	−0.3	0.3
	$g\ sin\theta$	C_{YG}	−1	1	1	−1	−0.2	0.2	0.2	−0.2
Vertical accelerations	a_{heave}	C_{ZH}	$0.7 - 0.4f_T$	$0.4f_T - 0.7$	$0.7 - 0.4f_T$	$0.4f_T - 0.7$	1	−1	1	−1
	a_{roll-z}	C_{ZR}	1	−1	−1	1	0.3	−0.3	−0.3	0.3
	$a_{pitch-z}$	C_{ZP}	0	0	0	0	0	0	0	0

Table 12 Load combination factors for OST load cases - fatigue assessment

Load component		*LCF*	*OST-1P*	*OST-2P*	*OST-1S*	*OST-2S*
Hull girder loads	M_{WV}	C_{WV}	-0.4	0.4	-0.4	0.4
	Q_{WV}	C_{QW}	$-0.4\ f_{\ell p}$	$0.4\ f_{\ell p}$	$-0.4\ f_{\ell p}$	$0.4\ f_{\ell p}$
	M_{WH}	C_{WH}	-1.0	1.0	1.0	-1.0
	M_{WT}	C_{WT}	$-f_{\ell_p\text{-}OST}$	$f_{\ell_p\text{-}OST}$	$f_{\ell_p\text{-}OST}$	$-f_{\ell_p\text{-}OST}$
Longitudinal accelerations	a_{surge}	C_{XS}	$-0.25 + 0.2f_T$	$0.25 - 0.2f_T$	$-0.25 + 0.2f_T$	$0.25 - 0.2f_T$
	$a_{pitch\text{-}x}$	C_{XP}	$0.4 - 0.2f_T$	$-0.4 + 0.2f_T$	$0.4 - 0.2f_T$	$-0.4 + 0.2f_T$
	$g\ \sin\varphi$	C_{XG}	$-0.4 + 0.2f_T$	$0.4 - 0.2f_T$	$-0.4 + 0.2f_T$	$0.4 - 0.2f_T$
Transverse accelerations	a_{sway}	C_{YS}	0	0	0	0
	$a_{roll\text{-}y}$	C_{YR}	$-0.4 + 0.6f_T$	$0.4 - 0.6f_T$	$0.4 - 0.6f_T$	$-0.4 + 0.6f_T$
	$g\ \sin\theta$	C_{YG}	$0.2 - 0.3f_T$	$-0.2 + 0.3f_T$	$-0.2 + 0.3f_T$	$0.2 - 0.3f_T$
Vertical accelerations	a_{heave}	C_{ZH}	-0.05	0.05	-0.05	0.05
	$a_{roll\text{-}z}$	C_{ZR}	$-0.4 + 0.6f_T$	$0.4 - 0.6f_T$	$0.4 - 0.6f_T$	$-0.4 + 0.6f_T$
	$a_{pitch\text{-}z}$	C_{ZP}	$0.4 - 0.2f_T$	$-0.4 + 0.2f_T$	$0.4 - 0.2f_T$	$-0.4 + 0.2f_T$

SECTION 3 SHIP MOTIONS AND ACCELERATIONS

Symbols

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

a_0 = acceleration parameter, shall be taken as:

$$a_0 = \left(1.58 - 0.47C_B\right)\left(\frac{2.4}{\sqrt{L}} + \frac{34}{L} - \frac{600}{L^2}\right)$$

T_θ = roll period, in s, as defined in [2.1.1]

θ = roll angle, in deg, as defined in [2.1.1]

T_φ = pitch period, in s, as defined in [2.1.2]

φ = pitch angle, in deg, as defined in [2.1.2]

R = vertical coordinate, in m, of the ship rotation centre, shall be taken as:

$$R = \min\left(\frac{D}{4} + \frac{T_{LC}}{2}, \frac{D}{2}\right)$$

C_{XG}, C_{XS}, C_{XP}, C_{YG}, C_{YS}, C_{YR}, C_{ZH}, C_{ZR}, and C_{ZP} = load combination factors, as defined in Sec.2

$a_{roll\text{-}y}$ = transverse acceleration due to roll, in m/s^2, as defined in [3.3.2]

$a_{pitch\text{-}x}$ = longitudinal acceleration due to pitch, in m/s^2, as defined in [3.3.1]

$a_{roll\text{-}z}$ = vertical acceleration due to roll, in m/s^2, as defined in [3.3.3]

$a_{pitch\text{-}z}$ = vertical acceleration due to pitch, in m/s^2, as defined in [3.3.3]

f_T = ratio between draught at a loading condition and scantling draught, shall be taken as:

$f_T = \frac{T_{LC}}{T_{SC}}$, but shall not be taken less than 0.5

T_{LC} = draught, in m, amidships for the considered loading condition. In case loading condition is not defined, $T_{LC} = T_{SC}$ shall be applied

x, y, z = X, Y and Z coordinates, in m, of the considered point with respect to the coordinate system, as defined in Sec.1 [1.2.1]

f_β = heading correction factor, shall be taken as:

for strength assessment:

f_β = 1.0 in general

f_β = 0.8 for BSR and BSP load cases for the extreme sea loads design load scenario

for fatigue assessment:

f_β = 1.0

f_{ps} = 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 for extreme sea loads design load scenario

f_{ps} = f_r for extreme sea loads design load scenario for vessels with service restriction

f_{ps} = 0.8 for the ballast water exchange design load scenario

f_{ps} = 0.8·f_r for the ballast water exchange design load scenario for vessels with service restriction

f_r = 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_R = factor related to the operational profile, as defined in Ch.9 Sec.4 [4.3].

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:

$$T_\theta = \frac{2.3\pi k_r}{\sqrt{g\,GM}}$$

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

$$\theta = \frac{9000\left(1.4 - 0.035T_\theta\right)f_p f_{BK}}{(1.15B + 55)\pi}$$

where:

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_R\left(0.23 - 4f_T B \cdot 10^{-4}\right)$ 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 ≤ B ≤ 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:

$$T_{\varphi} = \sqrt{\frac{2\pi\lambda_{\varphi}}{g}}$$

where:

$$\lambda_{\varphi} = 0.6\left(1 + f_T\right)L$$

The pitch angle, in deg, shall be taken as given in formula below and need not to be taken greater than 20 degree.

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

where:

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_R\left[\left(0.27 - 0.02 f_T\right) - \left(13 - 5 f_T\right) \cdot L \cdot 10^{-5}\right]$ 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

$f_p = f_R\left[0.27 - \left(15 + 4 f_T\right)L \cdot 10^{-5}\right]$ 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

$$f_p = f_R\left[0.24 - \left(6 - 2f_T\right)B \cdot 10^{-4}\right]$$ for fatigue assessment.

2.2.3 Heave acceleration

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

$$a_{heave} = 0.8(1 + 0.03v)\left(0.72 + \frac{2L}{700}\right)\left(1.15 - \frac{6.5}{\sqrt{gL}}\right)f_p a_0 g$$ $L < 100$ m

$$a_{heave} = \left(0.4 + \frac{L}{250}\right)\left(1 + 0.03v\left(3 - \frac{L}{50}\right)\right)\left(1.15 - \frac{6.5}{\sqrt{gL}}\right)f_p a_0 g$$ $100 \le L < 150$ m

$$a_{heave} = \left(1.15 - \frac{6.5}{\sqrt{gL}}\right)f_p a_0 g$$ $L \ge 150$ m

where:

v = unless otherwise specified in Pt.5, to be taken as:
0 kt for $L < 100$ m
5 kt for $L \ge 150$ m
linear interpolation for L between 100 m and 150 m.

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_R\left[\left(0.27 + 0.02f_T\right) - 17L \cdot 10^{-5}\right]$ for fatigue assessment.

2.2.4 Roll acceleration

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

$$a_{roll} = f_p \theta \frac{\pi}{180}\left(\frac{2\pi}{T_\theta}\right)^2$$

where:

θ = roll angle in deg, using f_p equal to 1.0

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_R\left[0.23 - 4f_T B \cdot 10^{-4}\right]$ for fatigue assessment.

2.2.5 Pitch acceleration

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

$$a_{pitch} = 0.8(1 + 0.05v)f_p\left(0.72 + \frac{2L}{700}\right)\left(1.75 - \frac{22}{\sqrt{gL}}\right)\varphi \frac{\pi}{180}\left(\frac{2\pi}{T_\varphi}\right)^2$$ $L < 100$ m

$$a_{pitch} = \left(0.4 + \frac{L}{250}\right)\left(1 + 0.05v\left(3 - \frac{L}{50}\right)\right) f_p \left(1.75 - \frac{22}{\sqrt{gL}}\right)\varphi \frac{\pi}{180}\left(\frac{2\pi}{T_\varphi}\right)^2$$ $100 \leq L < 150$ m

$$a_{pitch} = f_p \left(1.75 - \frac{22}{\sqrt{gL}}\right)\varphi \frac{\pi}{180}\left(\frac{2\pi}{T_\varphi}\right)^2$$ $L \geq 150$ m

where:

φ = pitch angle in deg, using f_p equal to 1.0
v = as defined in [2.2.3]
f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_R\left[0.28 - \left(5 + 6f_T\right)L \cdot 10^{-5}\right]$ 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:

$$a_X = f_\beta\left[\left(-C_{XG} g \sin\varphi\right) + C_{XS} a_{surge} + C_{XP} a_{pitch}(z - R)\right]$$

3.2.2 Transverse acceleration

The transverse acceleration at any position for each dynamic load case, in m/s^2, shall be taken as:

$$a_Y = f_\beta\left[C_{YG} g \sin\theta + C_{YS} a_{sway} - C_{YR} a_{roll}(z - R)\right]$$

3.2.3 Vertical acceleration

The vertical acceleration at any position for each dynamic load case, in m/s^2, shall be taken as:

$$a_Z = f_\beta\left[C_{ZH} a_{heave} + C_{ZR} a_{roll} y - C_{ZP} a_{pitch}(x - 0.45L)\right]$$

3.3 Envelope accelerations

3.3.1 Longitudinal acceleration

The envelope longitudinal acceleration in m/s^2, at any position, shall be taken as:

$$a_{x-env} = 0.7 f_L\left(0.65 + \frac{2z}{7T_{SC}}\right)\sqrt{a_{surge}^2 + \frac{L_0}{325}\left[g\sin\varphi + a_{pitch}(z-R)\right]^2}$$

where:

$a_{pitch\text{-}x}$ = longitudinal acceleration due to pitch, in m/s^2

$a_{pitch\text{-}x} = a_{pitch}(z-R)$

f_L = 1 for $L < 90$ m

= $1.3 - \frac{L}{300}$ for $90 \le L < 150$ m

= 0.8 for $L \ge 150$ m

3.3.2 Transverse acceleration

The envelope transverse acceleration in m/s^2, at any position, shall be taken as:

$$a_{y\text{-}env} = \left(1 - e^{-\frac{B\cdot L}{215GM}}\right)\sqrt{a_{sway}^2 + \left(g\sin\theta + a_{roll\text{-}y}\right)^2}$$

where:

$a_{roll\text{-}y}$ = transverse acceleration due to roll, in m/s^2

$a_{roll\text{-}y} = a_{roll}(z\text{-}R)$

3.3.3 Vertical acceleration

The envelope vertical acceleration for all headings in m/s^2, at any position, shall be taken as:

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

The envelope vertical acceleration for load combination head sea, see Table 1 in m/s^2, at any position, shall be taken as:

$$a_{z\text{-}env\text{-}pitch} = \sqrt{a_{heave}^2 + \left[\left(0.95 + e^{-\frac{L}{15}}\right)a_{pitch\text{-}z}\right]^2}$$

The envelope vertical acceleration for load combination beam sea, see Table 1 in m/s^2, at any position, shall be taken as:

$$a_{z\text{-}env\text{-}roll} = \sqrt{a_{heave}^2 + \left(1.2a_{roll\text{-}z}\right)^2}$$

where:

$a_{pitch\text{-}z}$ = vertical acceleration due to pitch, in m/s^2

$$a_{pitch\text{-}z} = a_{pitch}(1.08x - 0.45L)$$

$a_{roll\text{-}z}$ = vertical acceleration due to roll, in m/s^2

$$a_{roll\text{-}z} = a_{roll}\, y$$

3.3.4 Application of envelope accelerations for deck cargo units and heavy equipment

The accelerations acting on supporting structures and securing systems for heavy units of cargo, equipment or structural components (including cargo loads on hatch covers) shall be taken as given in Table 1.

Table 1 Load combinations for envelope accelerations

Load combination	$a_{x\text{-}U}$ 2)	$a_{y\text{-}U}$ 2)	$a_{z\text{-}U}$
Head sea 1	$a_{x\text{-}env}$	0	$a_{z\text{-}env\text{-}pitch}$
Head sea 2 1)	$a_{x\text{-}env}$	0	$- a_{z\text{-}env\text{-}pitch}$
Beam sea 1	0	$a_{y\text{-}env}$	$a_{z\text{-}env\text{-}roll}$
Beam sea 2 1)	0	$a_{y\text{-}env}$	$- a_{z\text{-}env\text{-}roll}$
Oblique sea 1	0.6 $a_{x\text{-}env}$	0.6 $a_{y\text{-}env}$	$a_{z\text{-}env}$
Oblique sea 2 1)	0.6 $a_{x\text{-}env}$	0.6 $a_{y\text{-}env}$	$- a_{z\text{-}env}$
1) Load combination is only applicable for uplift conditions. 2) The horizontal accelerations shall be applied in the direction(s) giving maximum response.			

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, shall be taken as:

$C_w = 0.0856L$ for $L < 90$

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

$C_w = 10.75$ for $300 < L \leq 350$

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

f_β = 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

for fatigue assessment:

$f_\beta = 1.0$

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

f_{fa} = 0.85; fatigue coefficient

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.

(See 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 m, and may upon consideration also be requested for smaller ships.

For ships with L ≤ 65 m, still water bending moment in seagoing condition defined in [2.2.1] and vertical still water shear force defined in [2.4.1] shall be taken as the rule minimum values. Smaller values shall be considered on a case-by-case basis and agreed with the Society.

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
— 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.

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

2.1.2 Still water loads for the fatigue assessment

The still water bending moment, shear force values and distribution for the fatigue assessment shall be typical values for the loading conditions that the ship will operate in for most of its life. The definition of loading conditions to be used 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:

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

Sagging conditions:

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

where:

$M_{wv\text{-}h\text{-}mid}$ = 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

$M_{wv\text{-}s\text{-}mid}$ = 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 for $x \leq 0$

f_{sw} = 0.15 at $x = 0.1\,L$

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.

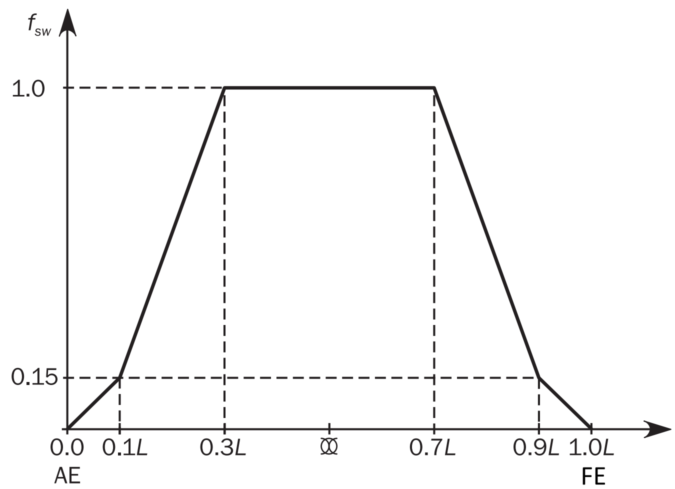


Figure 1 Distribution factor f_{sw}

2.2.2 Permissible vertical still water bending moment in seagoing condition

The permissible vertical still water bending moments, $M_{sw\text{-}h}$ and $M_{sw\text{-}s}$, 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, $M_{sw\text{-}p\text{-}h}$ and $M_{sw\text{-}p\text{-}s}$, 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 minimum design still water torsion moment in seagoing condition at any longitudinal position, in kNm, shall be taken as:

$$M_{st} = 20 \cdot B \cdot \sqrt{CC}$$

where:

CC = $n \cdot G$
n = maximum number of 20 ft containers (TEU)
G = maximum mass in tonnes of each TEU the ship can carry.

For global finite element analysis, 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} = 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:

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

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

where:

$M_{sw\text{-}min}$ = absolute maximum of $M_{sw\text{-}h\text{-}min}$ and $M_{sw\text{-}s\text{-}min}$ with f_{sw} = 1.0
f_{qs} = distribution factor along the ship length. May be taken as:

f_{qs} = 0.0 for $x \le 0$
f_{qs} = 1.0 at $0.15\,L \le x \le 0.3\,L$
f_{qs} = 0.8 for $0.4\,L \le x \le 0.6\,L$
f_{qs} = 1.0 at $0.7\,L \le x \le 0.85\,L$
f_{qs} = 0.0 for $x \ge L$

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, $Q_{sw\text{-}pos}$ and $Q_{sw\text{-}neg}$ 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, $Q_{sw\text{-}p\text{-}pos}$ and $Q_{sw\text{-}p\text{-}neg}$, 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:

$$M_{wv\text{-}h} = 0.19 \cdot \frac{f_R}{0.85} f_{n\ell\text{-}vh} f_m f_p C_w L^2 B C_B$$

Sagging condition:

$$M_{wv\text{-}s} = -0.19 \cdot \frac{f_R}{0.85} f_{n\ell\text{-}vs} f_m f_p C_w L^2 B C_B$$

where:

$f_{n\ell\text{-}vh}$ = coefficient considering non-linear effects applied to hogging, shall be taken as:

$f_{n\ell\text{-}vh}$ = 1.0 for strength and fatigue assessment

$f_{n\ell\text{-}vs}$ = coefficient considering non-linear effects applied to sagging, shall be taken as:

$f_{n\ell\text{-}vs} = 0.58\left(\frac{C_B + 0.7}{C_B}\right)$ for strength assessment

$f_{n\ell\text{-}vs} = 1.0$ for fatigue assessment

f_R = factor related to the operational profile, to be taken as:

= 0.85 for strength assessment

= as given in Ch.9 Sec.4 [4.3] for fatigue assessment

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_{fa} \cdot f_{vib}[0.27 - (6 + 4f_T)\, L \cdot 10^{-5}]$ for fatigue assessment

f_{vib} = correction for minimum contribution from hull girder vibration

= 1.10 for $B \leq 28$ m

= 1.20 for B > 40 m

= 1.15 for B > 40 m when North Atlantic is specified for other ships than ships with large deck openings, as defined in Ch.1 Sec.4 Table 7.

= Linear interpolation shall be applied in-between.

f_m = distribution factor for strength assessment for vertical wave bending moment along the ship's length, shall be taken as:

$f_m = 0.0$ for $x \le 0$

$f_m = 1.0$ for $0.4\,L \le x \le 0.65\,L$

$f_m = 0.0$ for $x \ge L$

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

= distribution factor for fatigue assessment for vertical wave bending moment along the ship's length, shall be taken as shown in Table 1 with linear interpolation in-between.

Table 1 Distribution factor for fatigue assessment for vertical wave bending moment along the ship's length

x/L	*full load*	*x/L*	*ballast*
0	0	0	0
0.05	0.05	0.15	0.15
0.1	0.14	0.2	0.25
0.3	0.74	0.4	0.83
0.35	0.86	0.45	0.93
0.4	0.94	0.5	0.98
0.45	0.99	0.55	1
0.5	1.	0.6	0.93
0.55	0.95	0.65	0.83
0.6	0.87	0.7	0.68
0.65	0.75	0.85	0.17
0.85	0.15	0.9	0.07
0.9	0.06	1	0
1	0		

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.

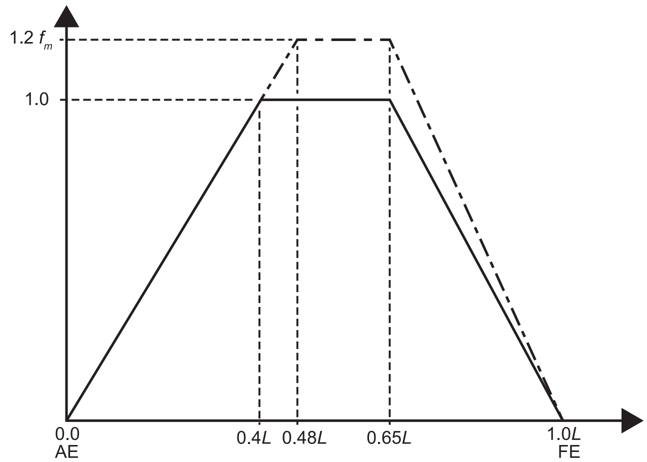


Figure 2 Distribution factor f_m, with and without adjustment

3.1.2 If required by [3.1.1] f_m shall be adjusted according to Table 2. See Figure 2.

Table 2 Adjustments to f_m

Load condition	*Sagging and hogging*		*Sagging only*	
C_{AV}	≤ 0.28	≥ 0.32 [1)]		
C_{AF}			≤ 0.40	≥ 0.50
f_m	No adjustment	1.2 between 0.48 L and 0.65 L from A.E. 0.0 at F.E. and A.E.	No adjustment	1.2 between 0.48 L and 0.65 L from A.E. 0.0 at F.E. and A.E.
1) Adjustment for C_{AV} shall not be applied when C_{AF} ≥ 0.50.				

C_{AV} = $\frac{c_v V}{\sqrt{L}}$

C_{AF} = $\frac{c_v V}{\sqrt{L}} + \frac{A_{DK} - A_{WP}}{L \cdot z_f}$

c_v = $\frac{\sqrt{L}}{50}$, maximum 0.2

A_{DK} = projected area in the horizontal plane of upper deck (including any forecastle deck) forward of 0.2 L from F.E., in m^2

A_{WP} = area of waterplane forward of 0.2 L from F.E. at draught T_{SC}, in m^2

z_f = vertical distance from summer load waterline to deckline measured at F.E., in m

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:

$$Q_{wv\text{-}pos} = 0.52\, f_{q\text{-}pos}\, f_p \cdot C_W\, L \cdot B \cdot C_B$$

$$Q_{wv\text{-}neg} = -(0.52\, f_{q\text{-}neg}\, f_p \cdot C_W\, L \cdot B \cdot C_B)$$

where:

f_p = coefficient shall be taken as:

$f_p = f_{ps}$	for strength assessment
$f_p = f_{fa} \cdot [0.27 - (17 - 8\, f_T)\, L \cdot 10^{-5}]$	for fatigue assessment

$f_{q\text{-}pos}$ = distribution factor along the ship length for positive wave shear force, shall be taken as shown in Figure 3

$f_{q\text{-}pos} = 0.0$	for $x \le 0$
$f_{q\text{-}pos} = 0.92\, f_{n\ell\text{-}h}$	for $0.2\, L \le x \le 0.3\, L$
$f_{q\text{-}pos} = 0.7\, f_{nl\text{-}s}$	for $0.4\, L \le x \le 0.6\, L$
$f_{q\text{-}pos} = 1.0\, f_{n\ell\text{-}s}$	for $0.7\, L \le x \le 0.85\, L$
$f_{q\text{-}pos} = 0.0$	for $x \ge L$

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

$f_{q\text{-}neg}$ = distribution factor along the ship length for negative wave shear force, shall be taken as shown in Figure 4

$f_{q\text{-}neg} = 0.0$	for $x \le 0$
$f_{q\text{-}neg} = 0.92\, f_{n\ell\text{-}s}$	for $0.2L \le x \le 0.3\, L$
$f_{q\text{-}neg} = 0.7\, f_{nl\text{-}s}$	for $0.4L \le x \le 0.6\, L$
$f_{q\text{-}neg} = 1.0\, f_{n\ell\text{-}h}$	for $0.7L \le x \le 0.85\, L$
$f_{q\text{-}neg} = 0.0$	for $x \ge L$

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

$f_{n\ell\text{-}h}, f_{n\ell\text{-}s}$ = 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 $f_{q\text{-}pos}$ and $f_{q\text{-}neg}$ as given in [3.2.2] apply for hull girder buckling strength check in accordance with Ch.8 Sec.3.

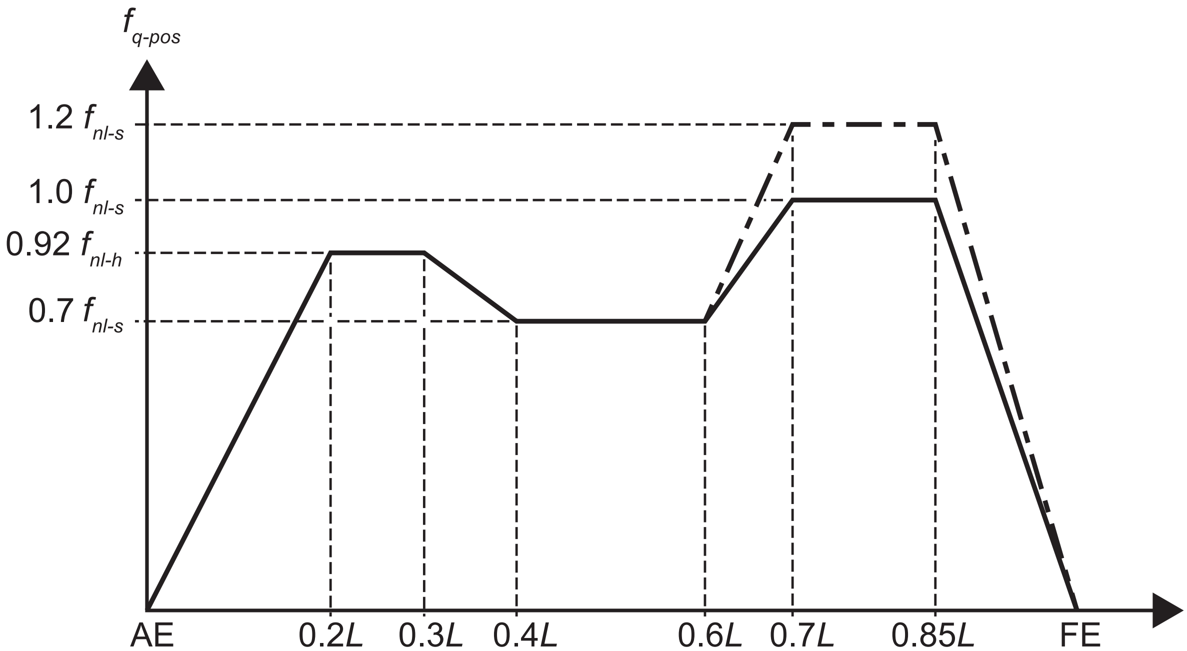


Figure 3 Distribution factor of positive vertical shear force f_{q-pos}, with and without adjustment

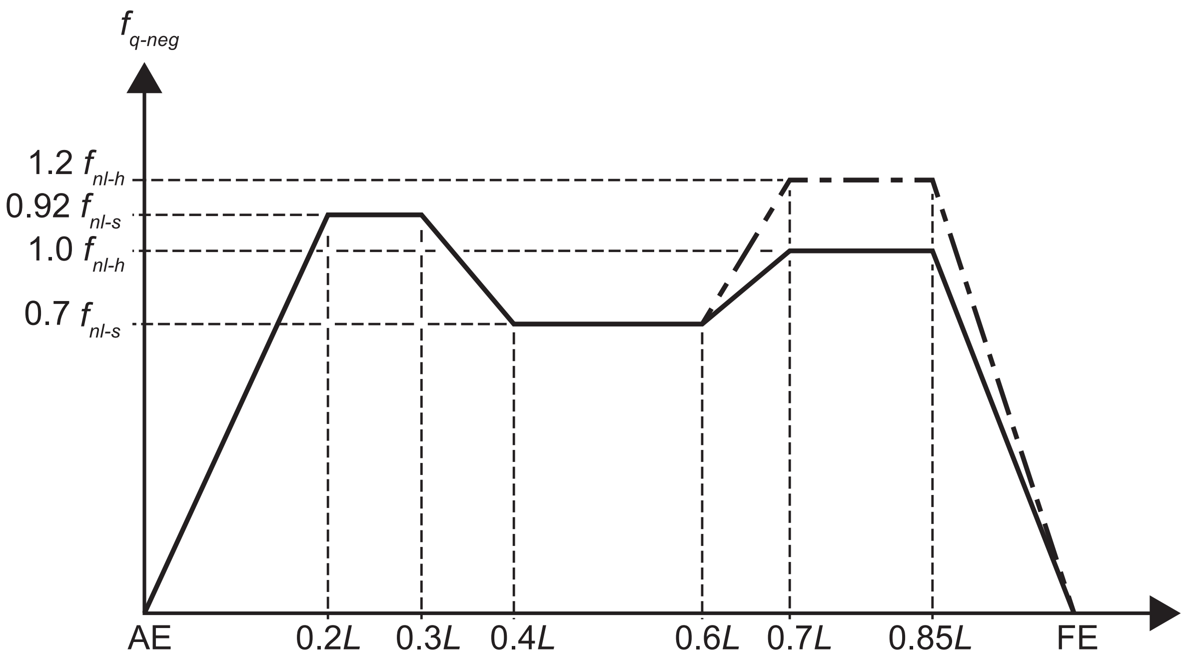


Figure 4 Distribution factor of negative vertical shear force $f_{q\text{-}neg}$, with and without adjustment

3.2.2 If required by [3.1.1] $f_{q\text{-}pos}$ and $f_{q\text{-}neg}$ shall be adjusted according to Table 3. See Figure 3 and Figure 4.

Table 3 Adjustments to $f_{q\text{-}pos}$ and $f_{q\text{-}neg}$

Load condition	*In connection with sagging and hogging wave bending moment*		*In connection with sagging wave bending moment only*	
C_{AV}	≤ 0.28	≥ 0.32 [1)]		
C_{AF}			≤ 0.40	≥ 0.50
Multiply $f_{q\text{-}pos}$ and $f_{q\text{-}neg}$ by	1.0	1.2 between 0.7 L and 0.85 L from A.E.	1.0	1.2 between 0.7 L and 0.85 L from A.E.
1) Adjustment for C_{AV} shall not be applied when C_{AF} ≥ 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:

$$M_{wh} = f_p\left(0.31 + \frac{L}{2800}\right)f_m C_w L^2 T_{LC} C_B$$

where:

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_{fa} \cdot [(0.2 + 0.04 f_T) + (11 - 8 f_T) L \cdot 10^{-5}]$ for fatigue assessment

f_m = 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:

$f_{\ell p\text{-}OST} = 5 f_{xL}$	for	$x/L < 0.2$
$f_{\ell p\text{-}OST} = 1.0$	for	$0.2 \le x/L < 0.4$
$f_{\ell p\text{-}OST} = -7.6 f_{xL} + 4.04$	for	$0.4 \le x/L < 0.65$
$f_{\ell p\text{-}OST} = -0.9$	for	$0.65 \le x/L < 0.85$
$f_{\ell p\text{-}OST} = 6 f_{xL} - 6$	for	$0.85 \le x/L$

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

$f_{\ell p\text{-}OSA} = -(0.2 + 0.3 f_T)$	for	$x/L < 0.4$
$f_{\ell p\text{-}OSA} = -(0.2 + 0.3 f_T)(5.6 - 11.5 f_{xL})$	for	$0.4 \le x/L < 0.6$
$f_{\ell p\text{-}OSA} = 1.3(0.2 + 0.3 f_T)$	for	$0.6 \le x/L$

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:

$$M_{wt} = f_p \left(M_{wt1} + M_{wt2} \right)$$

where:

$$M_{wt1} = 0.4 f_{t1} \cdot C_w \sqrt{\frac{L}{T_{LC}}} B^2 \cdot D \cdot C_B$$

$$M_{wt2} = 0.22 f_{t2} \cdot C_w \cdot L \cdot B^2 \cdot C_B$$

f_{t1}, f_{t2} = distribution factors, taken as:

$f_{t1} = 0$	for	$x < 0$
$f_{t1} = \left| \sin\left(\frac{360x}{L} \right) \right|$	for	$0 \le x \le L$
$f_{t1} = 0$	for	$x > L$

$f_{t2} = 0$ for $x < 0$

$f_{t2} = \sin^2\left(\frac{180x}{L}\right)$ for $0 \le x \le L$

$f_{t2} = 0$ for $x > L$

f_p = coefficient shall be taken as:

$f_p = f_{ps}$ for strength assessment

$f_p = f_{fa} \cdot [0.2 + (5f_T - 4.25)\, B \cdot 10^{-4}]$ 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, $M_{wv\text{-}LC}$, in kNm, shall be used for each dynamic load case in Sec.2, is defined in Table 4.

Table 4 Vertical wave bending moment for dynamic load cases

Load combination factor	$M_{wv\text{-}LC}$
$C_{WV} \ge 0$	$f_\beta\, C_{WV}\, M_{wv\text{-}h}$
$C_{WV} < 0$	$f_\beta\, C_{WV}\, \lvert M_{wv\text{-}s} \rvert$

where:

C_{WV} = load combination factor for vertical wave bending moment, shall be taken as specified in Sec.2

$M_{wv\text{-}h}$, $M_{wv\text{-}s}$ = 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, $Q_{wv\text{-}LC}$, in kN, shall be used for each dynamic load case in Sec.2, is defined in Table 5.

Table 5 Vertical wave shear force for dynamic load cases

Load combination factor	$Q_{wv\text{-}LC}$
$C_{QW} \ge 0$	$f_\beta\, C_{QW}\, Q_{wv\text{-}pos}$
$C_{QW} < 0$	$f_\beta\, C_{QW}\, \lvert Q_{wv\text{-}neg} \rvert$

where:

C_{QW} = load combination factor for vertical wave shear force, shall be taken as specified in Sec.2

$Q_{wv\text{-}pos}$, $Q_{wv\text{-}neg}$ = 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:

$$M_{wh\text{-}LC} = f_\beta \, C_{WH} \, M_{wh}$$

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:

$$M_{wt\text{-}LC} = f_\beta \, C_{WT} \, M_{wt}$$

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.

λ = 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:

$$f_{yB} = \frac{|2y|}{B_x} \quad \text{but not greater than 1.0}$$

$f_{yB} = 1$ when $B_x = 0$

f_{yB1} = ratio between Y-coordinate of the load point and B, to be taken as:

$$f_{yB1} = \frac{|2y|}{B} \quad \text{but not greater than 1.0}$$

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

$P_{W,WL} = P_W$ for $z = T_{LC}$ $y = B_x/2$ when $y \geq 0$
$y = -B_x/2$, 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

θ = roll angle, in deg, as defined in Sec.3 [2.1.1]

T_θ = roll period, in s, as defined in Sec.3 [2.1.1]

f_R = factor related to the operational profile, as defined in Ch.9 Sec.4 [4.3]

f_β = 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:

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

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 = hydrostatic pressure, in kN/m^2, is defined in [1.2]
P_W = 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/m^2, is obtained from Table 1. See also Figure 1.

Table 1 Hydrostatic pressure, PS

Location	*Hydrostatic pressure, P_S, in kN/m^2*
$z \le T_{LC}$	$\rho g\ (T_{LC}\text{-}z)$
$z > T_{LC}$	0

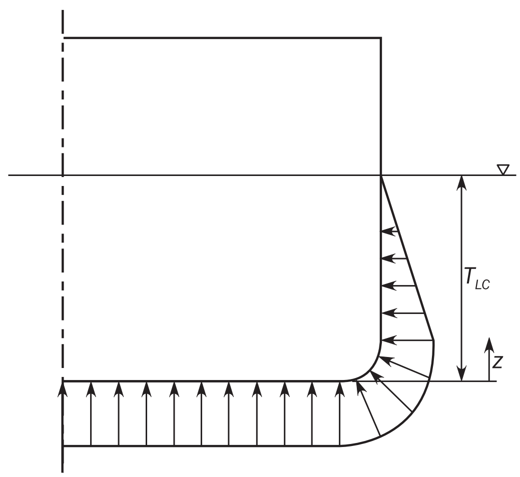


Figure 1 Transverse distribution of hydrostatic pressure Ps

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/m^2, shall be obtained from Table 2. See also Figure 2 and Figure 3.

Table 2 Hydrodynamic pressures for HSM load cases

	Wave pressure, in kN/m²		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
HSM-1	$P_W = \max\{-P_{HS}; \rho g(z - T_{LC})\}$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
HSM-2	$P_W = \max\{P_{HS}; \rho g(z - T_{LC})\}$		

where:

$$P_{HS} = C_{f_T} f_{ps} f_{n\ell} f_h k_a k_p f_{yz} C_w \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

C_{fT} = $f_T + 0.5 - (0.7 f_T - 0.2) C_B$

$f_{n\ell}$ = coefficient considering non-linear effects, to be taken as:

for extreme sea loads design load scenario:

$f_{n\ell} = 0.7$ at $f_{xL} = 0$

$f_{n\ell} = 0.9$ at $f_{xL} = 0.3$

$f_{n\ell} = 0.9$ at $f_{xL} = 0.7$

$f_{n\ell} = 0.6$ at $f_{xL} = 1$

for ballast water exchange design load scenario:

$f_{n\ell} = 0.85$ at $f_{xL} = 0$

$f_{n\ell} = 0.95$ at $f_{xL} = 0.3$

$f_{n\ell} = 0.95$ at $f_{xL} = 0.7$

$f_{n\ell} = 0.80$ 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:

$$k_a = \left(0.5 + f_T\right)\left[\left(3 - 2\sqrt{f_{yB}}\right) - \frac{20}{9} f_{xL}\left(7 - 6\sqrt{f_{yB}}\right)\right] + \frac{2}{3}\left(1 - f_T\right) \quad \text{for } f_{xL} < 0.15$$

$$k_a = 1.0 \quad \text{for } 0.15 \le f_{xL} < 0.7$$

$$k_a = 1 + \left(f_{xL} - 0.7\right)\left\{\left(\frac{40}{3} f_T - 5\right) + 2\left(1 - f_{yB}\right)\left[\frac{18}{C_B} f_T\left(f_{xL} - 0.7\right) - 0.25\left(2 - f_T\right)\right]\right\} \quad \text{for } f_{xL} \ge 0.7$$

λ = 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 3. Intermediate values shall be interpolated.

Table 3 Definition of phase coefficient K_p

f_{xL}	0	$0.3 - 0.1\ f_T$	$0.35 - 0.1\ f_T$	$0.8 - 0.2\ f_T$	$0.9 - 0.2\ f_T$	1.0
k_p	$-0.25\ f_T(1 + f_{yB})$	−1	1	1	−1	−1

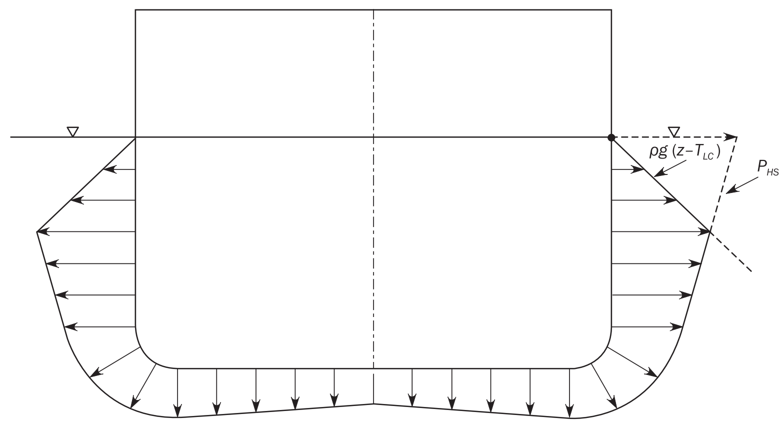


Figure 2 Transverse distribution amidships of dynamic pressure for HSM-1, HSA-1 and FSM-1 load cases

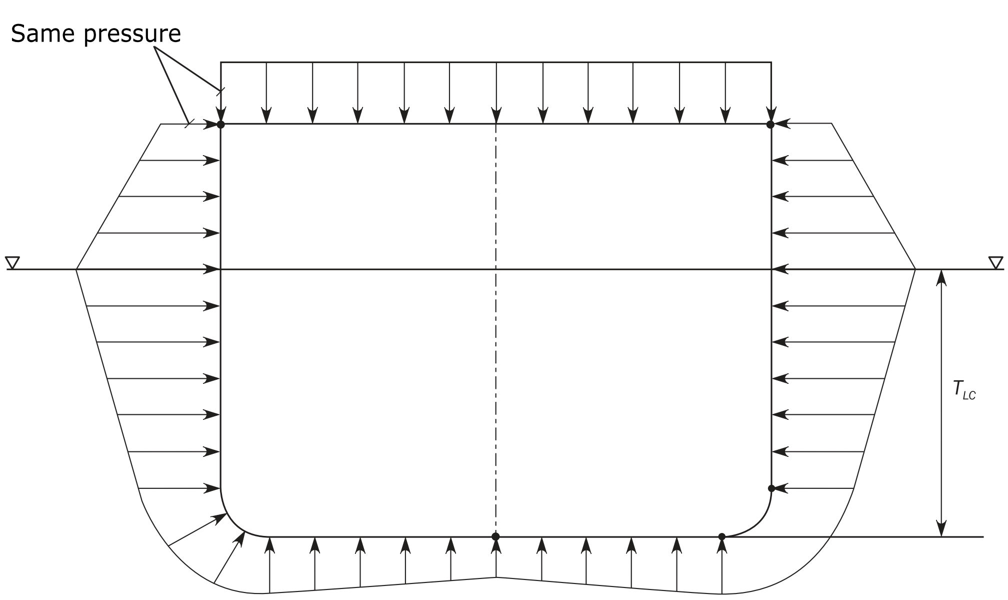


Figure 3 Transverse distribution amidships of dynamic pressure for HSM-2, HSA-2 and FSM-2 load cases

1.3.3 Hydrodynamic pressures for HSA load cases

The hydrodynamic pressures, P_W, for HSA-1 and HSA-2 load cases at any load point, in kN/m^2, shall be obtained from Table 4. See also Figure 2 and Figure 3.

Table 4 Hydrodynamic pressures for HSA load cases

	Wave pressure, in kN/m²		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
HSA-1	$P_W = \max\{-P_{HS}; \rho g(z - T_{LC})\}$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
HSA-2	$P_W = \max\{P_{HS}; \rho g(z - T_{LC})\}$		

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]
λ = 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 Definition of phase coefficient k_p

f_{xL}	*0*	*0.3 − 0.1 f_T*	*0.5 − 0.2 f_T*	*0.8 − 0.2 f_T*	*0.9 − 0.2 f_T*	*1.0*
k_p	$1.5 - f_T - 0.5\, f_{yB}$	−1	1	1	−1	−1

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

	Wave pressure, in kN/m²		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
FSM-1	$P_W = \max\{-P_{FS}; \rho g(z - T_{LC})\}$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
FSM-2	$P_W = \max\{P_{FS}; \rho g(z - T_{LC})\}$		

where:

$$P_{FS} = C_{f_T} f_{ps} f_{n\ell} f_h k_a k_p f_{yz} C_W \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

C_{fT} = coefficient to be taken as:

$$C_{f_T} = \left[1.0 + \left(1.5 - f_T\right)\left(C_B - 1.0\right)\right] \cdot \left(0.6 - 0.55\frac{L - 400}{300}\right)$$

$f_{n\ell}$ = coefficient considering non-linear effects, to be taken as:
$f_{n\ell}$ = 0.9 for extreme sea loads design load scenario
$f_{n\ell}$ = 0.95 for ballast water exchange design load scenarios

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

$$f_{yz} = \left(C_x - 0.2\right)\frac{z}{T_{LC}} + \left(2 - C_x\right)f_{yB} + 1.2$$

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 = 2.6

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

$$k_a = 1 + \left(3.75 - 2f_T\right)\left(1 - 5f_{xL}\right)\left(1 - f_{yB}\right) \quad \text{for} \quad f_{xL} < 0.2$$

$$k_a = 1.0 \quad \text{for} \quad 0.2 \le f_{xL} < 0.9$$

$$k_a = 1 + 20\left(1 - f_{yB}\right)\left(f_{xL} - 0.9\right) \quad \text{for} \quad f_{xL} \ge 0.9$$

λ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.6(1 + 2/3\, f_T)L$

k_p = phase coefficient to be obtained from Table 7. Intermediate values shall be interpolated.

Table 7 Definition of phase coefficient k_p

f_{xL}	0	$0.35 - 0.1f_T$	$0.5 - 0.2f_T$	0.75	0.8	1.0
k_p	$-0.75 - 0.25f_{yB}$	-1	1	1	-1	$-0.75 - 0.25f_{yB}$

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

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
BSR-1P	$P_W = \max(P_{BSR}, \rho g(z - T_{LC}))$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
BSR-2P	$P_W = \max(-P_{BSR}, \rho g(z - T_{LC}))$		
BSR-1S	$P_W = \max(P_{BSR}, \rho g(z - T_{LC}))$		
BSR-2S	$P_W = \max(-P_{BSR}, \rho g(z - T_{LC}))$		

where:

$$P_{BSR} = f_\beta f_{nl}\left[10y\sin\theta_1 + 0.88f_{ps}C_W\sqrt{\frac{L_0 + \lambda - 125}{L_0}}\left(f_{yB1} + 1\right)\right]$$

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

$$P_{BSR} = f_\beta f_{nl}\left[-10y\sin\theta_1 + 0.88 f_{ps} C_W \sqrt{\frac{L_0 + \lambda - 125}{L_0}}\left(f_{yB1} + 1\right)\right]$$

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

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

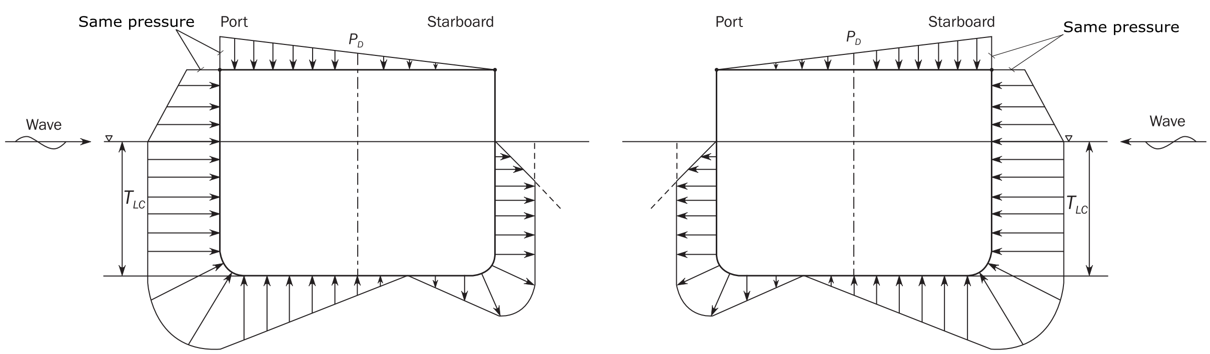
$f_{n\ell}$ = 1 for extreme sea loads design load scenario

$f_{n\ell}$ = 1 for ballast water exchange design load scenarios

λ = wave length of the dynamic load case, in m, to be taken as:

$\lambda = \frac{g}{2\pi} T_\theta^2$

θ_1 = $\theta_1 = \frac{9000\left(1.4 - 0,035 T_\theta\right)}{(1.15B + 55)\pi}$



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

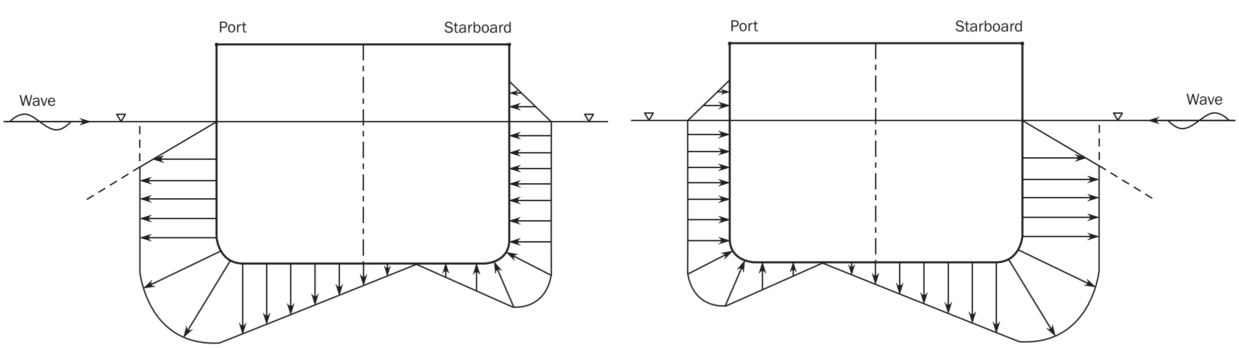


Figure 5 Transverse distribution of dynamic pressure for BSR-2P (left) and BSR-2S (right) load cases

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

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
BSP-1P	$P_W = \max(P_{BSP}, \rho g(z - T_{LC}))$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
BSP-2P	$P_W = \max(-P_{BSP}, \rho g(z - T_{LC}))$		
BSP-1S	$P_W = \max(P_{BSP}, \rho g(z - T_{LC}))$		
BSP-2S	$P_W = \max(-P_{BSP}, \rho g(z - T_{LC}))$		

where:

$$P_{BSP} = 4.5 f_{corr1} f_{corr2} f_\beta f_{ps} f_{n\ell} f_{yz} C_W \sqrt{\frac{L_0 + \lambda - 125}{L_0}}$$

λ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.2(1 + 2f_T)L_0$

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

Table 10 Definition of girth distribution coefficient f_{yz}

Transverse position	*BSP-1P - BSP-2P*	*BSP-1S - BSP-2S*
$y \ge 0$	$f_{yz} = 2\frac{z}{T_{LC}} + 2.5 f_{yB1} + 0.5$	$f_{yz} = \frac{2}{3}\frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$
$y < 0$	$f_{yz} = \frac{2}{3}\frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$	$f_{yz} = 2\frac{z}{T_{LC}} + 2.5 f_{yB1} + 0.5$

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

for extreme sea loads design load scenario:

$f_{n\ell} = 0.6$ at $f_{xL} = 0$

$f_{n\ell} = 0.8$ at $f_{xL} = 0.3$

$f_{n\ell} = 0.8$ at $f_{xL} = 0.7$

$f_{n\ell} = 0.6$ at $f_{xL} = 1$

for ballast water exchange design load scenario:

$f_{n\ell} = 0.6$ at $f_{xL} = 0$

$f_{n\ell} = 0.8$ at $f_{xL} = 0.3$

$f_{n\ell} = 0.8$ at $f_{xL} = 0.7$

$f_{n\ell} = 0.6$ at $f_{xL} = 1$

intermediate values are obtained by linear interpolation

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

$$= \left[0.9 + \left(\frac{2T_{LC}}{T_{SC}} - 1.05\right)\left(\frac{C_B}{0.85} - 0.85\right)\right] \cdot \left(1.03 - 0.16 f_T\right)$$

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

$$f_{corr2} = 1 + 0.25\frac{110}{L} \quad \text{for} \quad L < 110$$

$$f_{corr2} = 1.25 - 0.25\frac{L-110}{40} \quad \text{for} \quad 110 < L < 150$$

$$f_{corr2} = 1 \quad \text{for} \quad 150 < L$$

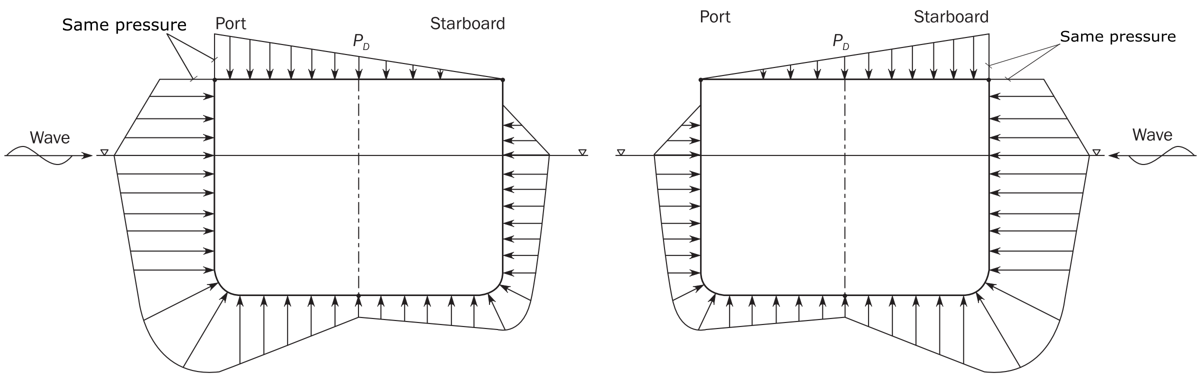


Figure 6 Transverse distribution of dynamic pressure for BSP-1P (left) and BSP-1S (right) load cases

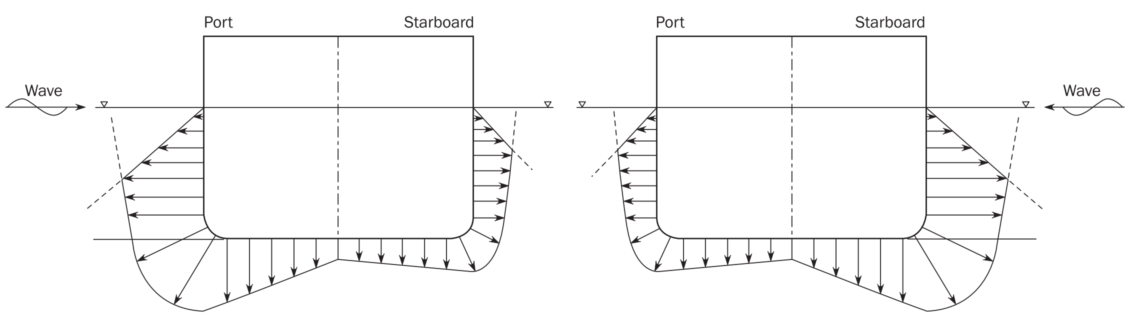


Figure 7 Transverse distribution of dynamic pressure for BSP-2P (left) and BSP-2S (right) load cases

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

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
OST-1P	$P_W = \max(P_{OST}, \rho g (z - T_{LC}))$	$P_W = P_{W,WL} - \rho g(z - T_{LC})$	$P_W = 0.0$
OST-2P	$P_W = \max(-P_{OST}, \rho g (z - T_{LC}))$		
OST-1S	$P_W = \max(P_{OST}, \rho g (z - T_{LC}))$		
OST-2S	$P_W = \max(-P_{OST}, \rho g (z - T_{LC}))$		

where:

$$P_{OST} = 1.38 f_{corr} f_{ps} f_{nl} k_a k_p f_{yz} C_W \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

f_{yz} = girth distribution coefficient, to be obtained from Table 12

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

$f_{n\ell} = 0.8$ for extreme sea loads design load scenario

$f_{n\ell} = 0.9$ for ballast water exchange design load scenarios

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

f_{corr} = coefficient, to be taken as:

$$f_{corr} = \begin{cases} \left(1.15 - 0.3 f_T\right)\left[1 + \left(f_T + 0.55\right)\dfrac{150 - L_0}{80}\right] & \text{for } L \le 150 \\ 1.15 - 0.3 f_T & \text{for } L > 150 \end{cases}$$

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 Definition of girth distribution coefficient f_{yz}

Transverse position	*OST-1P - OST-2P*	*OST-1S - OST-2S*
$y \ge 0$	$5\frac{z}{T_{LC}} + 3.5 f_{yB} + 1.5$	$1.5\frac{z}{T_{LC}} + 1.5$
$y < 0$	$1.5\frac{z}{T_{LC}} + 1.5$	$5\frac{z}{T_{LC}} + 3.5 f_{yB} + 1.5$

Table 13 Definition of amplitude coefficient K_a

Transverse position	*Longitudinal position*	*OST-1P - OST-2P*	*OST-1S - OST-2S*
$y \ge 0$	$f_{xL} \le 0.2$	$1 + 3.5\left(1 - f_{yB}\right)\left(1 - 5 f_{xL}\right)$	$1 + [3.5 - (4f_T - 0.5)f_{yB}](1 - 5f_{xL})$

Transverse position	*Longitudinal position*	*OST-1P - OST-2P*	*OST-1S - OST-2S*
	$0.2 < f_{xL} \leq 0.8$	1.0	1.0
	$f_{xL} > 0.8$	1.0	$1 + 4\left(1 - f_T\right)\left(5f_{xL} - 4\right)f_{yB}$
$y < 0$	$f_{xL} \leq 0.2$	$1 + \left[3.5 - \left(4f_T - 0.5\right)f_{yB}\right]\left(1 - 5f_{xL}\right)$	$1 + 3.5\left(1 - f_{yB}\right)\left(1 - 5f_{xL}\right)$
	$0.2 < f_{xL} \leq 0.8$	1.0	1.0
	$f_{xL} > 0.8$	$1 + 4\left(1 - f_T\right)\left(5f_{xL} - 4\right)f_{yB}$	1.0

Table 14 Definition of phase coefficient K_p

Transverse position	f_{xL}	*OST-1P - OST-2P*	*OST-1S - OST-2S*
$y \geq 0$	0.0	1.0	1.0
	0.2	1.0	$1 + \left(0.75 - 1.5f_T\right)f_{yB}$
	0.4	-1.0	$-1 + \left(1.75 - 0.5f_T\right)f_{yB}$
	0.5	-1.0	$-1 + \left(1.75 - 0.5f_T\right)f_{yB}$
	0.7	$-0.1 + \left(1.6f_T - 1.5\right)f_{yB}$	$-0.1 + \left(0.25 - 0.3f_T\right)f_{yB}$
	0.9	$0.8 + 0.2f_{yB}$	$0.8 - \left(0.9f_T + 0.85\right)f_{yB}$
	1.0	$-1 + f_{yB}$	$-1 + \left(0.5 - 0.5f_T\right)f_{yB}$
$y < 0$	0.0	1.0	1.0
	0.2	$1 + \left(0.75 - 1.5f_T\right)f_{yB}$	1.0
	0.4	$-1 + \left(1.75 - 0.5f_T\right)f_{yB}$	-1.0
	0.5	$-1 + \left(1.75 - 0.5f_T\right)f_{yB}$	-1.0
	0.7	$-0.1 + \left(0.25 - 0.3f_T\right)f_{yB}$	$-0.1 + \left(1.6f_T - 1.5\right)f_{yB}$
	0.9	$0.8 - \left(0.9f_T + 0.85\right)f_{yB}$	$0.8 + 0.2f_{yB}$
	1.0	$-1 + \left(0.5 - 0.5f_T\right)f_{yB}$	$-1 + f_{yB}$

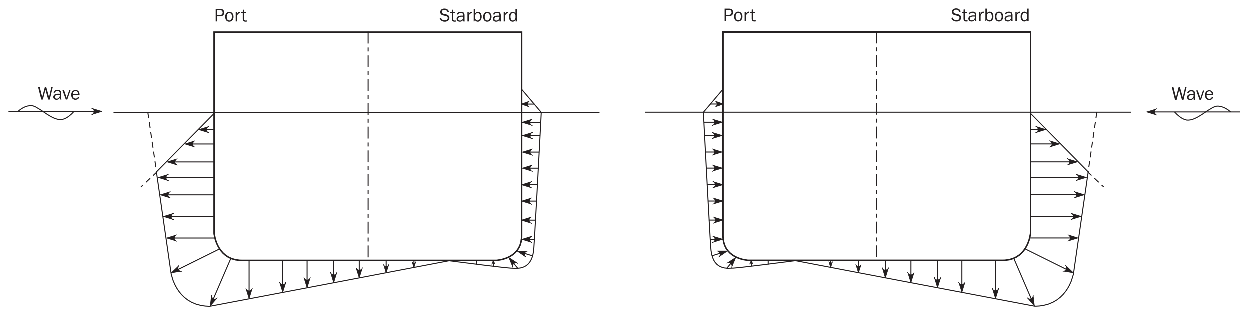


Figure 8 Transverse distribution of dynamic pressure amidships for OST-1P (left) and OST-1S (right) load cases

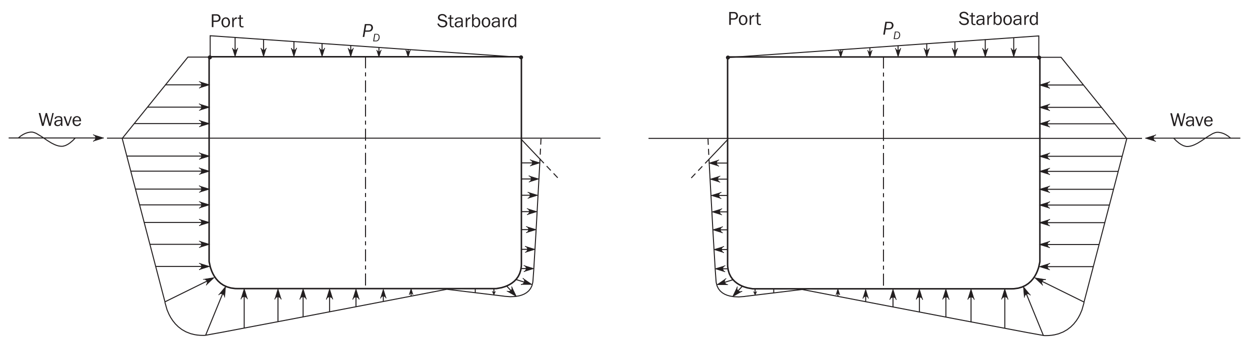


Figure 9 Transverse distribution of dynamic pressure amidships for OST-2P (left) and OST-2S (right) load cases

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

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le h_W + T_{LC}$	$z > h_W + T_{LC}$
OSA-1P	$P_W = \max\,(P_{OSA}, \rho g\,(z - T_{LC}))$	$P_W = P_{W,WL} - \rho g\,(z - T_{LC})$	$P_W = 0.0$
OSA-2P	$P_W = \max\,(-P_{OSA}, \rho g\,(z - T_{LC}))$		
OSA-1S	$P_W = \max\,(P_{OSA}, \rho g\,(z - T_{LC}))$		
OSA-2S	$P_W = \max\,(-P_{OSA}, \rho g\,(z - T_{LC}))$		

where:

$$P_{OSA} = 0.81 f_{corr} f_{ps} f_{nl} k_a k_p f_{yz} C_W \sqrt{\frac{L_0 + \lambda - 125}{L}}\left(1 + 0.5 f_T\right)$$

λ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.7\,L$

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

$$f_{corr} = (1.08 - 0.18 f_T)[1.25 + \ln(C_B)]$$ for $L < 80$

$$f_{corr} = (1.08 - 0.18 f_T)[1.25 + \ln(C_B)]\left[1 - \left(\frac{L}{20} - 4\right)(1 - \sin\alpha)\right]$$ for $80 \leq L < 100$

$$f_{corr} = (1.08 - 0.18 f_T)[1.25 + \ln(C_B)]\sin\alpha$$ for $L \geq 100$

$f_{n\ell}$ = coefficient considering non-linear effect, to be taken as:
for extreme sea loads design load scenario:
$f_{n\ell} = 0.5$ at $f_{xL} = 0$
$f_{n\ell} = 0.8$ at $f_{xL} = 0.3$
$f_{n\ell} = 0.8$ at $f_{xL} = 0.7$
$f_{n\ell} = 0.6$ at $f_{xL} = 1$
for ballast water exchange design load scenario:
$f_{n\ell} = 0.75$ at $f_{xL} = 0$
$f_{n\ell} = 0.9$ at $f_{xL} = 0.3$
$f_{n\ell} = 0.9$ at $f_{xL} = 0.7$
$f_{n\ell} = 0.8$ at $f_{xL} = 1$
intermediate values are obtained by linear interpolation

α = parameter in deg

$$\alpha = \frac{25T_{LC}}{L} \cdot \frac{180}{\pi}$$

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 Definition of girth distribution coefficient f_{yz}

Transverse position	*OSA-1P - OSA-2P*	*OSA-1S - OSA-2S*
$y \geq 0$	$5.5\frac{z}{T_{LC}} + 5.3 f_{yB} + 2.2$	$0.9\frac{z}{T_{LC}} + 0.4 f_{yB} + 2.2$
$y < 0$	$0.9\frac{z}{T_{LC}} + 0.4 f_{yB} + 2.2$	$5.5\frac{z}{T_{LC}} + 5.3 f_{yB} + 2.2$

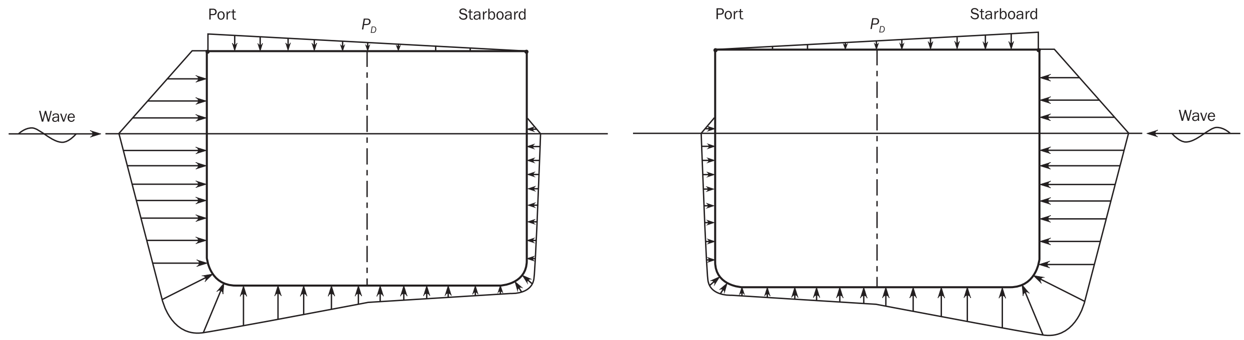


Figure 10 Transverse distribution of dynamic pressure amidships for OSA-1P (left) and OSA-1S (right) load cases

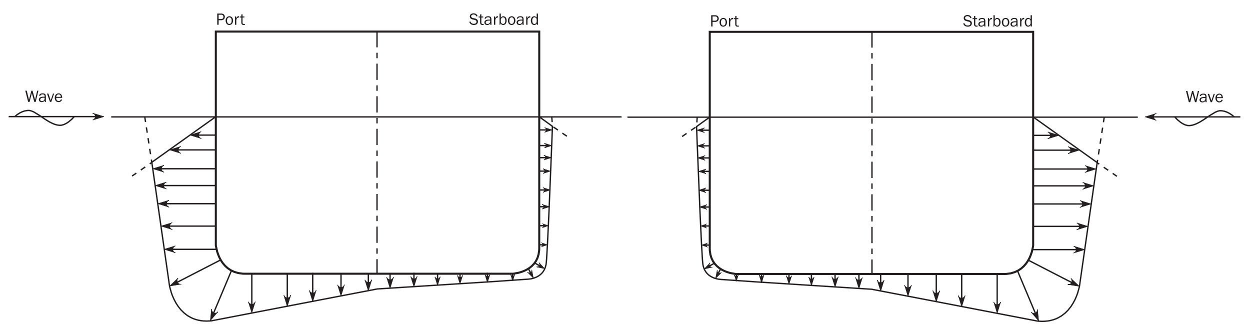


Figure 11 Transverse distribution of dynamic pressure amidships for OSA-2P (left) and OSA-2S (right) load cases

Table 17 Definition of amplitude coefficient K_a

Transverse position	*Longitudinal position*	*OSA-1P - OSA-2P*	*Longitudinal position*	*OSA-1S - OSA-2S*
y ≥ 0	$f_{xL} < 0.275$	$\min\{k_{a3};\ 1.05\}$	$f_{xL} < 0.35$	$1 + 4(f_T - 0.75)f_{yB}$ $+1.2f_{yB}\cos[90(5f_{xL} - 0.75)]$
	$0.275 < f_{xL} \leq 0.7$	$\min\{k_{a1};\ 1.05\}$	$0.35 < f_{xL} \leq 0.65$	k_{a2}
	$f_{xL} > 0.7$	$k_{a1} + (1.9f_T - 2.05)f_{yB}$ $\cos\left[\frac{180(f_{xL} - 0.4)}{0.6}\right]$	$f_{xL} > 0.65$	$k_{a2} + 36(f_{xL} - 0.65)^2 f_{yB}$
y < 0	$f_{xL} < 0.35$	$1 + 4(f_T - 0.75)f_{yB}$ $+1.2f_{yB}\cos[90(5f_{xL} - 0.75)]$	$f_{xL} < 0.275$	$\min\{k_{a3};\ 1.05\}$
	$0.35 < f_{xL} \leq 0.65$	k_{a2}	$0.275 < f_{xL} \leq 0.7$	$\min\{k_{a1};\ 1.05\}$
	$f_{xL} > 0.65$	$k_{a2} + 36(f_{xL} - 0.65)^2 f_{yB}$	$f_{xL} > 0.7$	$k_{a1} + (1.9f_T - 2.05)f_{yB}$ $\cos\left[\frac{180(f_{xL} - 0.4)}{0.6}\right]$

where:

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

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

$$k_{a3} = k_{a1} + (0.3f_T - 1.15)f_{yB}\cos\left[\frac{180(f_{xL} - 0.05)}{0.45}\right]$$

Table 18 Definition of phase coefficient K_p

Transverse position	*f_{xL} = x/L*	*OSA-1P and OSA-2P*	*OSA-1S and OSA-2S*[1)]
y ≥ 0	0.0	$0.75 - 0.5f_{yB}$	0.75
	0.1	$f_T - 0.25 + (1.25 - f_T)f_{yB}$	$f_T - 0.25 + (0.35f_T - 0.47)f_{yB}$
	0.35	1.0	$1 + (2.7f_T - 3.2)f_{yB}$
	0.4	$1.25 - 0.5f_T + (0.5f_T - 0.25)f_{yB}$	$1.25 - 0.5f_T + (2.7f_T - 3.2)f_{yB}$
	0.55	$1.5 - f_T + (f_T - 1.07)f_{yB}$	$1.5 - f_T + (2.7f_T - 3.2)f_{yB}$
	0.85	$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_{yB}$	$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_{yB}$
	1.0	$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_{yB}$	$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_{yB}$
y < 0	0.0	0.75	$0.75 - 0.5f_{yB}$
	0.1	$f_T - 0.25 + (0.35f_T - 0.47)f_{yB}$	$f_T - 0.25 + (1.25 - f_T)f_{yB}$
	0.35	$1 + (2.7f_T - 3.2)f_{yB}$	1.0
	0.4	$1.25 - 0.5f_T + (2.7f_T - 3.2)f_{yB}$	$1.25 - 0.5f_T + (0.5f_T - 0.25)f_{yB}$
	0.55	$1.5 - f_T + (2.7f_T - 3.2)f_{yB}$	$1.5 - f_T + (f_T - 1.07)f_{yB}$
	0.85	$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_{yB}$	$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_{yB}$
	1.0	$0.5f_T - 1.25 + (0.2 - 0.1f_T)f_{yB}$	$0.5f_T - 1.25 + (0.25 - 0.5f_T)f_{yB}$
1) 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 pressure

The envelope of wave pressure at any point, $P_{w\text{-}max}$, shall be taken as the greatest pressure obtained from any of the load cases determined by [1.3.2] to [1.3.8]. For ships with L=<90 m the envelope wave pressure, P_w, as obtained from Table 19 may be used in lieu of the pressures defined in [1.3.2] to [1.3.8].

Table 19 Wave pressure in kN/m^2, for ships with length ≤ 90 m

	Wave pressure in kN/m^2, for ships with length 90 m or less		
Load case	$z \leq T_{SC}$	$T_{SC} < z \leq h_w + T_{SC}$	$z > h_w + T_{SC}$
ENV	$P_W = P_{ENV}$	$P_W = P_{W,\,WL} - \rho g\left(z - T_{SC}\right)$	$P_W = 0$

P_{ENV}, shall be taken as the maximum of $P_{ENV\text{-}BS}$ and $P_{ENV\text{-}HS}$ where:

$$P_{ENV-BS} = f_r f_3\left(2 + \frac{55}{L}\right) f_{yz} C_w$$

$$P_{ENV-HS} = 5 f_r f_4 f_5\left(1 - \frac{C_B}{3}\right) C_w \sqrt{\frac{1.2L - 15}{L}}$$

where:

f_r = reduction factor related to service restriction as defined in Sec.3

f_3 = shall be taken as the greater of:
= 0.60
= 0.05+CB
= 1.1-0.1 L/B

f_4 = 2.0 when f_{xl}= 0
= 1.0 when f_{xl}= 0.2 to 0.6
= 3.0 when f_{xl}=1.0 and intermediate values to be obtained by linear interpolation

f_{yz} = $0.5z/T_{SC} + 2.5f_{yB} + 2$

f_5 = $0.2\left(4 + z/T_{SC}\right)$

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:

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

where:

P_S = hydrostatic pressure, in kN/m^2, defined in [1.2]
P_W = hydrodynamic pressure, in kN/m^2, 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 20.

Table 20 Hydrodynamic pressures for HSM load cases

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le 2h_W + T_{LC}$	$z > 2h_W + T_{LC}$
HSM-1	$P_w = \max\left\{-P_{HS}, \rho g\left(z - T_{LC}\right)\right\}$	$P_w = P_{w,wL} - \frac{1}{2}\rho g\left(z - T_{LC}\right)$	$P_w = 0.0$
HSM-2	$P_w = \max\left\{P_{HS}, \rho g\left(z - T_{LC}\right)\right\}$		

where:

$$P_{HS} = f_p f_h k_a k_p f_{yz} C_w \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

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:

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

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

$$k_a = 1 + 3f_T - \left(1 + f_T\right) f_{yB} + \left[5\left(1 + f_T\right) f_{yB} - 15 f_T\right] f_{xL} \quad \text{for } f_{xL} < 0.2$$

$$k_a = 1.0 \quad \text{for } 0.2 \le f_{xL} < 0.6$$

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

λ = 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 21. Intermediate values shall be interpolated.

Table 21 Definition of phase coefficient K_p

f_{xL}	k_P
0	$(1 - f_T) + (0.5 - f_T) f_{yB}$
$0.3 - 0.1 f_T$	-1
$0.5 - 0.2 f_T$	1
$0.9 - 0.4 f_T$	1
$0.9 - 0.2 f_T$	-1
1.0	-1

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/m^2, shall be obtained from Table 22.

Table 22 Hydrodynamic pressures for FSM load cases

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le 2h_W + T_{LC}$	$z > 2h_W + T_{LC}$
FSM-1	$P_w = \max\left\{-P_{FS}, \rho g\left(z - T_{LC}\right)\right\}$	$P_w = P_{w,wL} - \frac{1}{2}\rho g\left(z - T_{LC}\right)$	$P_w = 0.0$
FSM-2	$P_w = \max\left\{P_{FS}, \rho g\left(z - T_{LC}\right)\right\}$		

where:

$$P_{FS} = f_p f_h k_a k_p f_{yz} C_W \sqrt{\frac{L_0 + \lambda - 125}{L}}$$

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: $f_h = 2.6$

f_p = coefficient to be taken as: $f_p = f_R[(0.21 + 0.02\, f_T + (6 - 4\, f_T)L \cdot 10^{-5}]$

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

$$k_a = 1 + (3.5 - 2f_T)(1 - 5f_{xL})(1 - f_{yB}) \quad \text{for} \quad f_{xL} < 0.2$$

$$k_a = 1.0 \quad \text{for} \quad 0.2 \leq f_{xL} < 0.9$$

$$k_a = 1 + 15(1 - f_{yB})(f_{xL} - 0.9) \quad \text{for} \quad f_{xL} \geq 0.9$$

λ = wave length of the dynamic load case, in m, to be taken as:

$$\lambda = 0.6\left(1 + \tfrac{2}{3}f_T\right)L$$

k_p = phase coefficient to be obtained from Table 23. Intermediate values shall be interpolated.

Table 23 Definition of phase coefficient K_p

f_{xL}	k_P
0	$-0.75 - 0.25\,f_{yB}$
$0.35 - 0.1\,f_T$	-1
$0.5 - 0.2\,f_T$	1
0.75	1
$0.9 - 0.1\,f_T$	-1
1.0	$-0.5 - 0.5\,f_{yB}$

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/m^2, shall be obtained from Table 24.

Table 24 Hydrodynamic pressures for BSR load cases

<table>
<tr><th></th><th colspan="3">Wave pressure, in kN/m²</th></tr>
<tr><th>Load case</th><th>$z \leq T_{LC}$</th><th>$T_{LC} < z \leq 2h_W + T_{LC}$</th><th>$z > 2h_W + T_{LC}$</th></tr>
<tr><td>BSR-1P</td><td>$P_w = \max\{P_{BSR}, \rho g(z - T_{LC})\}$</td><td rowspan="4">$P_w = P_{w,wL} - \frac{1}{2}\rho g(z - T_{LC})$</td><td rowspan="4">$P_w = 0.0$</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>
</table>

where:

$$P_{BSR} = 10y\sin\theta + 0.88f_pC_W\sqrt{\frac{L_0 + \lambda - 125}{L_0}}(f_{yB1} + 1)$$

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

$$P_{BSR} = -10y\sin\theta + 0.88 f_p C_w \sqrt{\frac{L_0 + \lambda - 125}{L_0}}\left(f_{yB1} + 1\right)$$

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

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

λ = wave length of the dynamic load case, in m, to be taken as:

$$\lambda = \frac{g}{2\pi} T_\theta^2$$

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/m^2, shall be obtained from Table 25.

Table 25 Hydrodynamic pressures for BSP load cases

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le 2h_W + T_{LC}$	$z > 2h_W + T_{LC}$
BSP-1P	$P_w = \max\{P_{BSP}, \rho g(z - T_{LC})\}$	$P_w = P_{w,wL} - \frac{1}{2}\rho g(z - T_{LC})$	$P_w = 0.0$
BSP-2P	$P_w = \max\{-P_{BSP}, \rho g(z - T_{LC})\}$		
BSP-1S	$P_w = \max\{P_{BSP}, \rho g(z - T_{LC})\}$		
BSP-2S	$P_w = \max\{-P_{BSP}, \rho g(z - T_{LC})\}$		

where:

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

λ = wave length of the dynamic load case, in m, to be taken as: $\lambda = 0.2(1 + 2\, f_T)L_0$

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

$$f_{corr1} = \left[0.9 + \left(\frac{2T_{LC}}{T_{SC}} - 1.05\right)\left(\frac{C_B}{0.85} - 0.85\right)\right]\left(1.03 - 0.16 f_T\right)$$

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

$f_{corr2} = 1 + 0.25\frac{110}{L}$ for $L < 110$

$f_{corr2} = 1.25 - 0.25\frac{L - 110}{40}$ for $110 \le L < 150$

$f_{corr2} = 1$ for $150 \le L$

f_p = coefficient to be taken as:

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

f_{yz} = girth distribution coefficient, to be obtained from Table 26.

Table 26 Definition of girth distribution coefficient f_{yz}

Transverse position	*BSP-1P; BSP-2P*	*BSP-1S; BSP-2S*
y ≥ 0	$f_{yz} = 2\frac{z}{T_{LC}} + 2.5 f_{yB1} + 0.5$	$f_{yz} = \frac{2}{3}\frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$
y < 0	$f_{yz} = \frac{2}{3}\frac{z}{T_{LC}} + \frac{1}{2} f_{yB1} + 0.5$	$f_{yz} = 2\frac{z}{T_{LC}} + 2.5 f_{yB1} + 0.5$

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 27.

Table 27 Hydrodynamic pressures for OST load cases

	Wave pressure, in kN/m^2		
Load case	$z \le T_{LC}$	$T_{LC} < z \le 2h_W + T_{LC}$	$z > 2h_W + T_{LC}$
OST-1P	$P_w = \max\{P_{OST}, \rho g(z - T_{LC})\}$	$P_w = P_{w,wL} - \frac{1}{2}\rho g(z - T_{LC})$	$P_w = 0.0$
OST-2P	$P_w = \max\{-P_{OST}, \rho g(z - T_{LC})\}$		
OST-1S	$P_w = \max\{P_{OST}, \rho g(z - T_{LC})\}$		
OST-2S	$P_w = \max\{-P_{OST}, \rho g(z - T_{LC})\}$		

where:

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

f_{yz} = girth distribution coefficient, to be obtained from Table 28

Table 28 Definition of girth distribution coefficient f_{yz}

Transverse position	*OST-1P; OST-2P*	*OST-1S; OST-2S*
y ≥ 0	$5\frac{z}{T_{LC}} + 3.3 f_{yB} + 1.7$	$\frac{z}{T_{LC}} + 0.3 f_{yB} + 1.7$
y < 0	$\frac{z}{T_{LC}} + 0.3 f_{yB} + 1.7$	$5\frac{z}{T_{LC}} + 3.3 f_{yB} + 1.7$

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

λ = 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 29

k_p = phase coefficient to be obtained from Table 30. Intermediate values shall be interpolated.

Table 29 Definition of amplitude coefficient K_a

Transverse position	*Longitudinal position*	*OST-1P; OST-2P*	*OST-1S; OST-2S*
y ≥ 0	$f_{xL} \leq 0.2$	$1 + \left[\left(3.5 - 2f_T\right) + \left(10f_T - 17.5\right)f_{xL}\right]\left(1 - f_{yB}\right)$	$1 + \left(3.5 - 2f_T - 1.5f_{yB}\right)$ $+\left(10f_T - 17.5 + 7.5f_{yB}\right)f_{xL}$
	$0.2 < f_{xL} \leq 0.8$	1.0	1.0
	$f_{xL} > 0.8$	1.0	$1 + 2\left(1 - f_T\right)\left(5f_{xL} - 4\right)f_{yB}$
y < 0	$f_{xL} \leq 0.2$	$1 + \left(3.5 - 2f_T - 1.5f_{yB}\right)$ $+\left(10f_T - 17.5 + 7.5f_{yB}\right)f_{xL}$	$1 + \left[\left(3.5 - 2f_T\right)\right.$ $\left.+\left(10f_T - 17.5\right)f_{xL}\right]\left(1 - f_{yB}\right)$
	$0.2 < f_{xL} \leq 0.8$	1.0	1.0
	$f_{xL} > 0.8$	$1 + 2\left(1 - f_T\right)\left(5f_{xL} - 4\right)f_{yB}$	1.0

Table 30 Definition of phase coefficient K_p

Transverse position	f_{xL}	*OST-1P - OST-2P*	*OST-1S - OST-2S*
y ≥ 0	0.0	1.0	$1 + \left(0.5 - f_T\right)f_{yB}$
	0.2	1.0	$1 + 3\left(0.5 - f_T\right)f_{yB}$
	0.4	−1.0	$\left(2.7 - 2.4f_T\right)f_{yB} - 1$
	0.5	−1.0	$\left(2.8 - 2.6f_T\right)f_{yB} - 1$
	0.7	$\left(f_T - 0.62\right)f_{yB} - 0.38$	$\left(2.38 - 3f_T\right)f_{yB} - 0.38$
	0.9	$0.24 + 0.76f_{yB}$	$0.24 - \left(0.24 + f_T\right)f_{yB}$
	1.0	$-1 + 0.5f_{yB}$	−1.0
y < 0	0.0	$1 + \left(0.5 - f_T\right)f_{yB}$	1.0
	0.2	$1 + 3\left(0.5 - f_T\right)f_{yB}$	1.0
	0.4	$\left(2.7 - 2.4f_T\right)f_{yB} - 1$	−1.0
	0.5	$\left(2.8 - 2.6f_T\right)f_{yB} - 1$	−1.0
	0.7	$\left(2.38 - 3f_T\right)f_{yB} - 0.38$	$\left(f_T - 0.62\right)f_{yB} - 0.38$
	0.9	$0.24 - \left(0.24 + f_T\right)f_{yB}$	$0.24 + 0.76f_{yB}$

Transverse position	f_{xL}	OST-1P - OST-2P	OST-1S - OST-2S
	1.0	−1.0	$-1 + 0.5f_{yB}$

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:

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

where:

$P_{W,D}$ = pressure in kN/m^2 obtained at ship's side, at vertical coordinate equal to z_{dk} for HSM, HSA and FSM load cases as defined in [1.3]

$P_{D\text{-}min}$ = minimum pressure on exposed freeboard deck, in kN/m^2, to be taken as:

for global or partial ship finite element analysis according to Ch.7: $P_{D\text{-}min} = 0$

for PSM grillage according to Ch.6 Sec.6: $P_{D\text{-}min} = 0$

for other cases: $P_{D\text{-}min}$ as defined in Table 31

χ = reduction factor for pressure on exposed deck above freeboard deck:

$\chi = 0.75^C$, when $C < 3$

$\chi = 2.5 / P_{D\text{-}min}$, when $C \geq 3$

$\chi = 0$, when $P_{D\text{-}min} = 0$

$\chi = 1.0$ for freeboard deck

C = $(z_{dk} - z_{fdk})/2.3$

z_{fdk} = distance from baseline to freeboard deck considered at side, in m
z_{dk} = distance from baseline to lowest point of the exposed deck considered, in m
z = distance from baseline to load point, 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 $\chi P_{D\text{-}min}$, see Figure 12. Forward and aft of the recess the pressure may be tapered linearly down to the line as shown in Figure 12. The minimum pressure $\chi P_{D\text{-}min}$ for the weather deck shall be applied to the exposed deck in way of the recess.

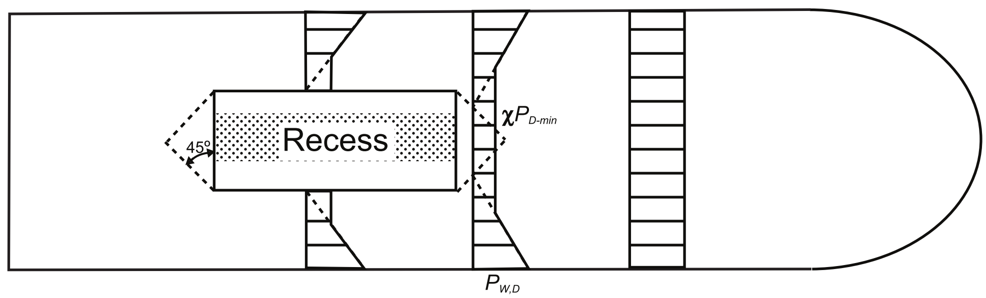


Figure 12 Transverse distribution of green sea pressure head sea

Table 31 Minimum pressures on exposed decks for HSM, HSA, FSM load cases

Location	*Minimum pressure on exposed freeboard deck, $P_{D\text{-}min}$, in kN/m²*	
	$L_{LL} \geq 100$ m	$L_{LL} < 100$ m
$\frac{x_{LL}}{L_{LL}} \leq 0.75$	34.3	$14.9 + 0.195\, L_{LL}$
$\frac{x_{LL}}{L_{LL}} > 0.75$	$34.3 + \left[14.8 + a(L_{LL} - 100)\right]\left(4\frac{x_{LL}}{L_{LL}} - 3\right)$	$12.2 + \frac{L_{LL}}{9}\left(5\frac{x_{LL}}{L_{LL}} - 2\right) + 3.6\frac{x_{LL}}{L_{LL}}$

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/m², 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):

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

where:

$P_{W,D\text{-}int}$ = pressure obtained by linear interpolation in transverse direction to the transverse coordinate of the load point between $P_{W,D\text{-}stb}$ and $P_{W,D\text{-}pt}$

$P_{W,D\text{-}stb}$ = pressure obtained at ship's starboard side, at vertical coordinate equal to z_{dk} for BSR, BSP, OST or OSA load cases as defined in [1.3], as appropriate

$P_{W,D\text{-}pt}$ = pressure obtained at ship's port side, at vertical coordinate equal to z_{dk} for BSR, BSP, OST and OSA load cases as defined in [1.3], as appropriate

z = as defined in [2.2.3]

z_{dk} = as defined in [2.2.3]

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 may be tapered linearly down to 0 at a line as shown in Figure 13.

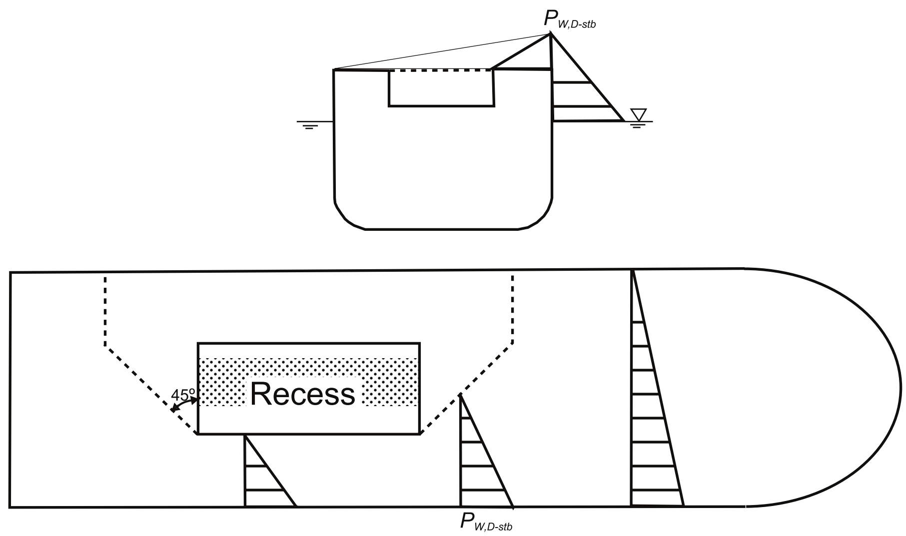


Figure 13 Transverse distribution of green sea pressure in beam sea

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:

$P_{dl\text{-}s}$ = static pressure, in kN/m^2, due to the distributed load, minimum 2.5 kN/m^2, including selfweight, unless a higher load is defined by the designer

$P_{dl\text{-}d}$ = dynamic pressure, in kN/m^2, due to the distributed load

= $P_{dl\text{-}s} \cdot a_z/g$

a_Z = vertical envelope acceleration, in 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 longitudinal force $F_{U\text{-}x}$, transverse force $F_{U\text{-}y}$ and vertical force $F_{U\text{-}z}$, in kN, due to this concentrated load for the static plus dynamic (S + D) design load scenarios shall be taken as:

$$F_{U\text{-}x} = m_U\, a_{x\text{-}U}$$

$$F_{U\text{-}y} = m_U\, a_{y\text{-}U}$$

$$F_{U\text{-}z} = F_{U\text{-}s} + m_U\, a_{z\text{-}U}$$

$F_{U\text{-}s}$ = static force, in kN, due to the unit load to be taken equal to:

= $m_U\, g$

m_U = mass of the unit load carried, in t

$a_{x\text{-}U}$, $a_{y\text{-}U}$ and $a_{z\text{-}U}$ = envelope accelerations, in m/s^2, as defined in Sec.3 [3.3.4].

Guidance note:

1) For heavy units with centre of gravity (COG) less 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, the horizontal accelerations, $a_{x\text{-}U}$ and $a_{y\text{-}U}$, may be neglected.

2) The longitudinal force $F_{U\text{-}x}$, transverse force $F_{U\text{-}y}$ and vertical force $F_{U\text{-}z}$ in kN, due to this concentrated load for the static plus dynamic (S + D) design load scenarios may be derived for each dynamic load case when these forces are considered in combination with hull girder loads.

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

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:

$$P_{SI} = 3C_W(C_B + 0.7) - 2.2(z - T_{sc}) \quad \text{for } z < 1.7\ C_w \text{ above WL at } T_{sc}$$

$$P_{SI} = 2.5 \quad \text{for } z \geq 1.7\ C_w \text{ above WL at } T_{sc}$$

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:

$$P_A = f_n f_c\left[f_b f_d - (z_w - T_{SC})\right]$$

but shall not be less than $p_{A\text{-}min}$

where:

f_n = coefficient defined in Table 32
f_c = coefficient, to be taken as:

$$f_c = 0.3 + 0.7\frac{b_1}{B_1} \quad \text{but not less than } 0.475$$

For exposed parts of machinery casings, f_c shall not be taken less than 1.0
f_d = coefficient, to be taken as:

$$f_d = \frac{L}{10}e^{\frac{-L}{300}} - \left[1 - \left(\frac{L}{150}\right)^2\right] \quad \text{for } L < 150 \text{ m}$$

$$f_d = \frac{L}{10}e^{\frac{-L}{300}} \quad \text{for } 150 \text{ m} \leq L < 300 \text{ m}$$

$$f_d = 11.03 \quad \text{for } L \geq 300 \text{ m}$$

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 33
$P_{A\text{-}min}$ = minimum lateral pressure, in kN/m^2, as defined in Table 34.

z_W = vertical distance, in m, taken at mid-height of the bulkhead or wall with respect to the reference coordinate system defined in Sec.1 [1.2.1]

Guidance note:

Longitudinal deckhouse walls in recesses with limited length and protected from green sea loads may be defined as superstructure side, hence [3.3] applies.

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

Table 32 Definition of coefficient f_n

Type of bulkhead	*Location*	f_n
Unprotected front bulkhead 1)	Lowest tier 2)	$20 + \frac{L_2}{12}$
	Second tier	$10 + \frac{L_2}{12}$
	Third tier and above	$5 + \frac{L_2}{15}$
Protected front bulkhead 1)	All tiers	$5 + \frac{L_2}{15}$
Side bulkheads	All tiers	$5 + \frac{L_2}{15}$
Aft end bulkheads	Abaft amidships	$7 + \frac{L_2}{100} - 8\frac{x}{L_2}$
	Forward of amidships	$5 + \frac{L_2}{100} - 4\frac{x}{L_2}$

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 2nd tier and the tier above as the 3rd tier.

Table 33 Definition of coefficient f_b

Location of bulkhead 1)	f_b
$\frac{x}{L} < 0.45$	$1 + \left(\frac{\frac{x}{L} - 0.45}{C_{B1} + 0.2}\right)^2$
$\frac{x}{L} \geq 0.45$	$1 + 1.5\left(\frac{\frac{x}{L} - 0.45}{C_{B1} + 0.2}\right)^2$

Location of bulkhead[1)]	f_b
where: C_{B1} = block coefficient, but not less than 0.60 nor greater than 0.80. For aft deckhouse bulkheads located forward of amidships, C_{B1} 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 34 Definition of minimum lateral pressure $P_{A\text{-}min}$

	$P_{A\text{-}min}$, in kN/m^2	
L	*Lowest tier of unprotected fronts*	*Elsewhere* [1)]
$L \leq 250$	$25 + \frac{L}{10}$	$12.5 + \frac{L}{20}$
$L > 250$	50	25
1) For the 4th tier and above, $P_{A\text{-}min}$ 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 35.

Table 35 Design pressure for windows

Structure	*Design pressure [kN/m^2]*
Superstructure side	Max(P_W; P_{SI})
Deckhouse side walls	P_A
Aft wall	
Front wall	

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 and Z 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 and Z 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 = longitudinal, transverse and vertical accelerations, in m/s^2, at x_G, y_G, z_G, as defined in Sec.3 [3.2]

ρ_L = density of liquid in the tank and ballast hold, in t/m^3, normally not to be taken less than:

1) *Strength assessment:*

   ρ_L = 1.025 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. $\rho_{max\text{-}LM}$ > 1.025), then ρ_L = $\rho_{max\text{-}LM}$

2) *Fatigue assessment:*

   ρ_L = 0.9 for oil and oil product cargoes

   ρ_L = 1.025 for ballast tanks

   $\rho_L = \rho_{max\text{-}LM}$ for cargo tanks intended to carry liquid other than oil products and for cargo tanks intended to carry oil products with density exceeding 1.025 t/m^3

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

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

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

ρ_{slh} = liquid density, in t/m^3, to be used for sloshing assessment, taken as:

$\rho_{slh} = \rho_{part}$	for heavy liquid cargo density associated with partial filling of cargo tank
$\rho_{slh} = \rho_L$	for all other cases

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

f_{cd} = 0.88	for strength assessment with FE analysis of cargo tanks filled with for oil or oil products cargo with $\rho_L \le 1.025$ t/m^3
f_{cd} = 1.0	for other cases

ρ_{ST} = density of steel, in t/m^3

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

h_{air} = height of air pipe or overflow pipe above the top of the tank, in m

P_{PV} = design vapour pressure, in kN/m^2, not to be taken less than 25 kN/m^2 and not greater than 70 kN/m^2. Design vapour pressure greater than 70 kN/m^2 may be accepted on a case-by-case basis

ϕ = pitch angle, in deg, defined in Sec.3 [2.1.2]

θ = roll angle, in deg, defined in Sec.3 [2.1.1]

T_θ = roll period, in s, as defined in Sec.3 [2.1.1]
f_β = coefficient defined in Sec.4.

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/m^2, for the static (S) design load scenarios, given in Sec.7, shall be taken as:

$$P_{in} = P_{\ell s} \text{ but not less than } 0$$

The internal pressure due to liquid acting on any load point of a tank and ballast hold boundary, in kN/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:

$$P_{in} = P_{\ell s} + P_{\ell d} \text{ but not less than } 0$$

where:

$P_{\ell s}$ = static pressure due to liquid in tanks and ballast holds, in kN/m^2, as defined in [1.2.1] to [1.2.6]
$P_{\ell d}$ = dynamic inertial pressure due to liquid in tanks and ballast holds, in kN/m^2, as defined in [1.3].

1.1.2 Pressures for the strength assessments of flooded conditions

The internal pressure in flooded condition, in kN/m^2, 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/m^2, as defined in [1.2.7].

1.2 Static liquid pressure

1.2.1 Normal operations at sea

The static pressure, in kN/m^2, in tanks and ballast holds for normal operations at sea, shall be taken as:

$P_{\ell s\text{-}1} = f_{cd}\,\rho_L\,g\left(z_{top} - z\right) + P_{PV}$ for tanks arranged with pressure relief valves

$P_{\ell s\text{-}1} = \rho_L\,g\left(z_{top} - z\right)$ 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:

$$P_{ls\text{-}2} = p_L g\left(z_{top} - z + h_{drop}\right) + P_{drop\text{-}1}$$

where:

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

$P_{drop\text{-}1}$ = overpressure, in kN/m^2, during flow through ballast water exchange. $P_{drop\text{-}1}$ 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:

$$P_{\ell s\text{-}3} = \rho_L\, g\left(z_{top} - z\right) + P_{PV}$$ for cargo tanks arranged with pressure relief valves

$$P_{\ell s\text{-}3} = \rho_L\, g\left(z_{top} - z\right) + P_0$$ 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	$50 \text{ m} < L < 100$ m
$P_0 = 25$	for	$L \geq 100$ m

for tanks designed for emptying with air overpressure:

P_0 = max air overpressure. Air overpressure above 70kN/m shall be considered case by case

for ballast hold in dry cargo vessels:

$P_0 = 0$

1.2.4 Overfilling of tanks

The static pressure, in kN/m^2, due to ballast water overfilling or fresh water overfilling, if applicable, shall be taken as:

$$P_{\ell s\text{-}4} = \rho_L\, g\left(z_{top} - z + h_{air}\right) + P_{drop\text{-}2}$$

where:

$P_{drop\text{-}2}$ = overpressure in kN/m^2, not to be taken less than:

= 25 kN/m^2 in general for ballast water tanks

= 0 kN/m^2 when tanks are not intended for overfilling during ballasting. In such case, means to be provided to avoid accidental overfilling, e.g. remote sounding for the ballast system or an electronic ballast system to adjust general draft and trim condition

= 25 kN/m^2 in general for fresh water tanks which will be filled until overflow through air pipe

= 0 kN/m^2 when fresh water tanks are not intended for overfilling.

1.2.5 Tank testing

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

$$P_{\ell s\text{-}ST} = 10\left(z_{ST} - z\right)$$

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}

Compartment	z_{ST}
Double bottom tanks	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{bd}$
Hopper side tanks[1], topside tanks[1], double side tanks[1], fore and aft peaks used as tank	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{top} + 2.4$
Tanks, deep tanks, fuel oil bunkers, cargo tanks[2]	The greater of the following: z_{ST}[3] $= z_{top} + h_{air}$ $z_{ST} = z_{top} + 2.4$ $z_{ST} = z_{top} + 0.1\ P_{PV}$
Ballast hold	$z_{ST} = z_h + 0.9$
Chain locker	$z_{ST} = z_c$
Independent tanks	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{top} + 0.9$
Ballast ducts	Testing load height corresponding to ballast pump maximum pressure

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:

$$P_{\ell s} = \rho_L\, g\left(z_{top} - z\right)$$

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} = pressure height, in m, in flooded condition, to be taken as:

$$h_{fs} = \max\left\{Z_{fd} - Z; |Y|\sin\theta_{dam} + \left(Z_{dam} - Z\right)\cos\theta_{dam}\right\}$$

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

Z_{dam} = Z coordinate, in m, of the deepest equilibrium waterline at centre line in the damaged condition (or in intermediate stages of flooding)

θ_{dam} = angle, in degrees, between the deepest equilibrium waterline in the damaged condition (or in intermediate stages of flooding) 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/m^2 shall be taken as:

$$P_{\ell d} = f_{cd}\,\rho_L\left[a_Z\left(z_0 - z\right) + f_{ull-\ell}\,a_x\left(x_0 - x\right) + f_{ull-t}\,a_y\left(y_o - y\right)\right]$$

where:

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

for strength assessment:

$f_{ull\text{-}\ell}$ = 0.62 for cargo tanks filled with any liquids inclusive water ballast

$f_{ull\text{-}\ell}$ = 1.0 for other cases

for fatigue assessment:

$$f_{ull-\ell} = 0.5 + \frac{\left|z_0 - z\right|}{\ell_{fs}}\frac{180}{\varphi\pi}$$ for cargo tanks and ballast holds

$f_{ull\text{-}\ell}$ = 1.0 for other cases

$f_{ull\text{-}\ell}$ shall not be less than 0.0 nor greater than 1.0

ℓ_{fs} = cargo tank length at the top of the tank or length of the ballast hold hatch coaming, in m

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

for strength assessment:

$f_{ull\text{-}t}$ = 0.67 for cargo tanks filled with any liquids inclusive water ballast

$f_{ull\text{-}t}$ = 1.0 for other cases

for fatigue assessment:

$$f_{ull-t} = 0.5 + \frac{\left|z_0 - z\right|}{b_{top}}\frac{180}{\theta\pi}$$ for cargo tanks and ballast holds

$f_{ull\text{-}t}$ = 1.0 for other cases

b_{top} = cargo tank breadth at the top of the tank or breadth of the ballast hold hatch coaming, in m determined at mid length of the tank or ballast hold hatch coaming

x_0 = X coordinate, in m, of the reference point

y_0 = Y coordinate, in m, of the reference point

z_0 = Z 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_{top} of the top of the tank or the ballast hold hatch coaming is acceptable, see Figure 1:

$$x_j = x_{top} \pm 0.5\,\ell_{fs}$$

$$y_j = y_{top} \pm 0.5 b_{top}$$

where

x_{top} = X coordinate, in m, of the centre of the rectangular area A_{top} at the top of the tank or the ballast hold hatch coaming

y_{top} = Y coordinate, in m, of the centre of the rectangular area A_{top} at the top of the tank or the ballast hold hatch coaming

A_{top} = $\ell_{fs} \cdot b_{top}$: the area of an rectangular shape at the top of the tank or the ballast hold hatch coaming, in m^2.

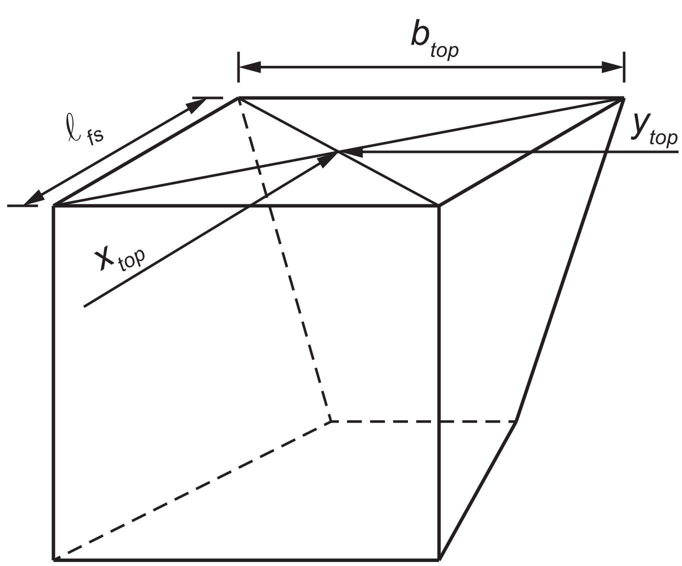


Figure 1 Area of a rectangular shape at the top of a tank

1.3.2 Dynamic liquid pressure for ships with $L \leq 90$ m

The dynamic pressure, in kN/m^2, due to liquid in tanks for ships with $L \leq 90$ m, may be taken as the maximum of:

$$P_{\ell d} = \rho_L \left[0.6 a_{x-env} \left| x_0 - x \right| + 0.6 a_{y-env} \left| y_0 - y \right| + a_{z-env} \left| z_0 - z \right| \right] \text{ or}$$

$$P_{\ell d} = \rho_L k_1 \left[a_{x-env} \left| x_0 - x \right| \right] \text{ or}$$

$$P_{\ell d} = \rho_L k_2 \left[a_{y-env} \left| y_0 - y \right| \right] \text{ or}$$

$$P_{\ell d} = 15$$

where:

x_0 = x coordinate, in m, of the point in the middle of the upper boundary of the tank
y_0 = y coordinate, in m, of the point in the middle of the upper boundary of the tank
z_0 = z coordinate, in m, of the point in the middle of the upper boundary of the tank
k_1 = 2
k_2 = 1.2

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 (0.25 t/m^2 distributed mass) for accommodation decks, tween decks and platforms in general
— 3.5 kN/m^2 (0.35 t/m^2 distributed mass) for wheelhouse deck
— 8 kN/m^2 (0.8 t/m^2 distributed mass) 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:

$$P_{it} = 12$$

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]

$M_{sw\text{-}p}$ = permissible hull girder hogging and sagging still water bending moment for harbour/sheltered operations, in kNm, as defined in Ch.5 Sec.2 [1.7]

$M_{sw\text{-}i}$ = permissible hull girder hogging and sagging still water bending moment for special operations, in kNm

$M_{wv\text{-}LC}$ = 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

$M_{wh\text{-}LC}$ = 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

$M_{wt\text{-}LC}$ = 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]

$Q_{sw\text{-}p}$ = permissible hull girder positive and negative still water shear force limits for harbour/sheltered operations, in kN, as defined in Ch.5 Sec.2 [2.3.1]

$Q_{sw\text{-}i}$ = permissible hull girder positive and negative still water shear force limits for special operations, in kNm

$Q_{wv\text{-}LC}$ = 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/m^2

P_S = static sea pressure at considered draught, in kN/m^2, as defined in Sec.5 [1.2.1]

P_W = dynamic pressure for a considered dynamic load case, in kN/m^2, 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/m^2, as defined in Sec.5 [2.2.3] and Sec.5 [2.2.4]

P_{in} = design internal pressure, in kN/m^2

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

P_{ST} = tank testing pressure, in kN/m^2, see Sec.6 [1.2.5]

$P_{\ell s\text{-}1}$ = static tank pressure during normal operations at sea as given in Sec.6 [1.2.1]

$P_{\ell s\text{-}2}$ = static tank pressure during flow through ballast water exchange as given in Sec.6 [1.2.2]

$P_{\ell s\text{-}3}$ = static tank pressure during normal operations at harbour/sheltered water as given in Sec.6 [1.2.3]

$P_{\ell s\text{-}4}$ = static tank pressure during overfilling of ballast water tanks as given in Sec.6 [1.2.4]

$P_{\ell d}$ = dynamic liquid pressure in tank for a considered dynamic load case, in kN/m^2, as defined in Sec.6 [1.3]

P_{bs} = dry bulk cargo static pressure, in kN/m^2, as defined in Pt.5 Ch.1 Sec.2

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

P_{fs} = static pressure in compartments and tanks in flooded condition, in kN/m^2, as defined in Sec.6 [1.2.7]

$P_{d\ell\text{-}s}$ = static pressure on non-exposed decks and platforms, in kN/m^2, as defined in Sec.6 [2.2.1]

$P_{d\ell\text{-}d}$ = dynamic pressure on non-exposed decks and platforms for a considered dynamic load case, in kN/m^2, as defined in Sec.6 [2.2.1]

$F_{U\text{-}s}$ = 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]

$F_{U\text{-}d}$ = dynamic load acting on supporting structures and securing systems for heavy units of 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.

Guidance note:

The load scenario special operations address' particular operations like temporarily submerged condition of a ship with the class notation **Semi-submersible heavy transport vessel**, special crane operations or pipe laying operations.

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

Table 1 Principal design load scenarios

				Design load scenario						
				1	*2*	*3*	*4*	*5*	*6*	*7*
				Normal operations at harbour and sheltered water	*Normal operation at sea*	*Flow through ballast water exchange*	*Overfilling of ballast tanks and tank testing*	*Flooding*	*Special operation stillwater* 3)	*Special operations at sea* 3)
				Static (S)	*Static + dynamic (S + D)*	*Static + dynamic (S + D)*	*Static (S) and (T)*	*Static (S)*	*Static (S)*	*Static + dynamic (S+D)*
Load component	Hull girder loads		VBM	M_{sw}	M_{sw} + $M_{wv\text{-}LC}$	M_{sw} + $M_{wv\text{-}LC}$	M_{sw}	M_{sw}	M_{sw_i}	$M_{sw\_i} + M_{wv\text{-}LC}$
			HBM	-	$M_{wh\text{-}LC}$	$M_{wh\text{-}LC}$	-	-	-	$M_{wh\text{-}LC}$
			VSF	Q_{sw}	Q_{sw} + $Q_{wv\text{-}LC}$	Q_{sw} + $Q_{wv\text{-}LC}$	-	-	Q_{sw_i}	$Q_{sw\_i} + Q_{wv\text{-}LC}$
			TM 2)	M_{st}	M_{st} + $M_{wt\text{-}LC}$	M_{st} + $M_{wt\text{-}LC}$	M_{st}	M_{st}	M_{st_i}	$M_{st\_i} + M_{wt\text{-}LC}$
	Local loads	P_{ex}	Exposed decks	-	P_D	-	-	-	P_s	$P_S + P_W$
			External shell	P_S	$P_S + P_W$	$P_S + P_W$	P_S	-	P_s	$P_S + P_W$
			Superstructure sides	-	max(P_W; P_{SI})	-	-	-	P_s	$P_S + P_W$
			Superstructure end bulkheads and deckhouse walls	-	P_A	-	-	-	P_s	$P_S + P_W$
		P_{in}	Boundaries of water ballast tanks 1)	$P_{\ell s\text{-}3}$	$P_{\ell s\text{-}1}$ + $P_{\ell d}$	$P_{\ell s\text{-}2}$ + $P_{\ell d}$	max($P_{\ell s\text{-}4}$, $P_{\ell s\text{-}ST}$)	-	$P_{\ell s\text{-}3}$	$P_{\ell s\text{-}1} + P_{\ell d}$
			Boundaries of tanks other than water ballast tanks			-	$P_{\ell s\text{-}ST}$	-	$P_{\ell s\text{-}3}$	$P_{\ell s\text{-}1} + P_{\ell d}$
			Watertight boundaries	-	-	-	-	P_{fs}	-	-
			Boundaries of bulk cargo holds	P_{bs}	P_{bs} + P_{bd}	-	-	-	-	-
			Internal structures in tanks	P_{int}		-	-	-	-	-
		$P_{d\ell}$	Exposed decks and non-exposed decks and platforms	$P_{d\ell\text{-}s}$	$P_{d\ell\text{-}s}$ + $P_{d\ell\text{-}d}$	-	-	-	$P_{d\ell\text{-}s}$	$P_{d\ell\text{-}s} + P_{d\ell\text{-}d}$

				Design load scenario						
				1	2	3	4	5	6	7
				Normal operations at harbour and sheltered water	*Normal operation at sea*	*Flow through ballast water exchange*	*Overfilling of ballast tanks and tank testing*	*Flooding*	*Special operation stillwater*[3)]	*Special operations at sea*[3)]
				Static (S)	*Static + dynamic (S + D)*	*Static + dynamic (S + D)*	*Static (S) and (T)*	*Static (S)*	*Static (S)*	*Static + dynamic (S+D)*
		F_U	Heavy units on internal and external decks	F_{U-s}	F_{U-s} + F_{U-d}	-	-	-	F_{U-s}	$F_{U-s} + F_{U-d}$
		P_{wl}	Decks and hatch covers/ RoRo equipment	P_{wl-1}	P_{wl-2}	-	-	-	-	-

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.
3) Maximum permissible stillwater loads, both hull girder loads and local loads, for special operation shall be used both for static (S) and static+dynamic (S+D) load scenario. The dynamic loads shall be based on the maximum permissible seastate for the considered operation.

Design load scenarios for ships with *L* ≤ 90 m

2.1.2 For ships with L ≤ 90 m the design load scenarios given in Table 2 may be used as an alternative to those given in Table 1.

Table 2 Principal design load scenarios for ships with *L* ≤ 90 m

			Design load scenario			
			1	2	4	5
			Normal operations at harbour and sheltered water	*Normal operation at sea*	*Overfilling of ballast tanks and tank testing*	*Flooding*
Load component		VBM	M_{sw}	$M_{sw} + M_{wv}$	M_{sw}	-
	P_{ex}	Exposed decks	-	P_D	-	-
		External shell	P_S	$P_S + P_W$	P_S	-
		Superstructure sides	-	Max$\{P_W; P_{SI}\}$	-	-
		Superstructure end bulkheads and deckhouse walls	-	P_A	-	-
	P_{in}	Boundaries of water ballast tanks	$P_{\ell s-3}$	$P_{\ell s-1} + P_{\ell d}$	Max$\{P_{\ell s-4}; P_{\ell s-ST}\}$	-

			Design load scenario			
			1	2	4	5
			Normal operations at harbour and sheltered water	*Normal operation at sea*	*Overfilling of ballast tanks and tank testing*	*Flooding*
		Boundaries of tanks other than water ballast tanks			$P_{\ell s\text{-}ST}$	-
		Watertight boundaries	-	-	-	P_{fs}
		Boundaries of bulk cargo holds	P_{bs}	$P_{bs} + P_{bd}$	$P_{bs} + P_{bd}$	-
		Internal structures in tanks	P_{int}	-	-	-
	$P_{d\ell}$	Exposed decks and non-exposed decks and platforms	$P_{d\ell\text{-}s}$	$P_{d\ell\text{-}s} + P_{d\ell\text{-}d}$	-	-
	F_U	Heavy units on internal and external decks	$F_{U\text{-}s}$	$F_{U\text{-}s} + F_{U\text{-}d}$	-	-
	P_{wl}	Decks and hatch covers/RoRo equipment	$P_{wl\text{-}1}$	$P_{wl\text{-}2}$	-	-

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 3.

Table 3 Design load scenarios for fatigue assessment

			Design load scenario
			Fatigue
			Static + dynamic (F: S + D)
Load component	Hull girder loads	VBM	$M_{sw} + M_{wv\text{-}LC}$
		HBM	$M_{wh\text{-}LC}$
		VSF	$Q_{sw} + Q_{wv\text{-}LC}$
		TM [2)]	$M_{wt\text{-}LC}$

				Design load scenario
				Fatigue
				Static + dynamic (F: S + D)
	Local loads	P_{ex}	Exposed decks	-
			External shell	$P_S + P_W$
		P_{in}	Boundaries of water ballast tanks [1)]	$P_{\ell s} + P_{\ell d}$
			Boundaries of tanks other than water ballast tanks	
			Watertight bulkheads	
			Boundaries of bulk cargo holds	$P_{bs} + P_{bd}$
		$P_{d\ell}$	Exposed decks and non-exposed decks and platforms	-
		F_U	Heavy units on internal and external decks	-

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 vessels 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 10% 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.

See Pt.5 for standard loading conditions for different ship types.

CHANGES – HISTORIC

July 2018 edition

Changes July 2018, entering into force 1 January 2019

Topic	*Reference*	*Description*
Load improvements	Sec.3 [2.1.2]	Max pitch angle 20 degrees introduced.
	Sec.6 [1.2.3]	Parameter described for tanks designed for emptying with air overpressure.
	Sec.5 [1.3.6]	Length L_0 is introduced in formula for pressure and formula for wave length at the same time as the correction factor f_{corr2} is modified.
	Sec.2 Table 4	Load combination factors for longitudinal accelerations are modified.
	Sec.2 Table 6	
	Sec.3 [3.3.1]	The formula is modified.
	Sec.5 [1.3.5]	Length L_0 is introduced in formula for pressure. Roll pressure for ultimate strength is made not dependent on bilge keel.
	Sec.5 [1.3.7]	The factor f_{corr} is modified.
	Sec.5 [1.4.4]	Length L_0 is introduced in formula for pressure.
	Sec.5 [1.4.5]	Length L_0 is introduced in formula for pressure and formula for wave length at the same time as the correction factor f_{corr2} is modified.
Simplification ships L ≤ 90 m	Sec.7 [2.1.2]	New subsection for ships with L ≤ 90 m.
	Sec.6 [1.3.2]	New subsection describing dynamic liquid pressure for ships with L <= 90 m.
	Sec.5 [1.3.9]	Formula for envelope pressure for ships with L = 90 m and below is introduced.
Special operations	Sec.7	List of symbols is updated with description of hull girder parameters for special operation load scenario.
	Sec.7 Table 1	Table update for special operations.
	Sec.7 [2.1.1]	Clarification of the term *special operation*.
Revision of rule text	Sec.6 [1.2.5]	Tank testing re-established for small tanks, e.g. in engine room.

February 2018 edition

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

The January 2018 edition was erroneously published with 6 months in force date. The following changes enter into force from January 2018.

Topic	*Reference*	*Description*
Adjustment of fatigue loads.	Sec.4 [3.1.1]	The routing factor f_R is introduced in vertical bending moment formulas. The hull girder vibration factor is increased for container vessels and the wave bending moment distribution is modified.
	Sec.4 [3]	The factor f_{fa} is introduced on all hull girder loads.
	Sec.4	Definition of f_{fa} is introduced.
	Sec.5 [1.4]	f_p is updated by replacing f_{fa} with f_R. This applies to all pressure formulas for fatigue wave pressure.
	Sec.5	Definition of f_R is introduced.
Clarification of liquid cargo density.	Sec.6	Clarification of liquid cargo density applicable for fatigue assessment has been made. Also application of factor for joint probability, f_{cd}, has been clarified.
Combination of envelope accelerations.	Sec.3 [3.3.3]	Inserted new vertical accelerations for considerations of pitch and roll separately.
	Sec.3 [3.3.4]	New paragraph and table.
	Sec.5 [2.3.2]	The application of accelerations on concentrated loads is modified.
Definition of flooding pressure.	Sec.6 [1.2.7]	The definition of pressure height w.r.t. flooding has been updated to also include intermediate stages of flooding. This is required by SOLAS.
Improvement of rules for vessels below 90 m.	Sec.4 [2.1.1]	For vessel of length less than 65 metres, the rule still water bending moments and shear force are applied as minimum values unless calculated values are provided.
	Sec.5 [2.2.3]	Adding clarification for application of minimum exposed freeboard deck pressure can be applied for both cargo hold analysis and PSM grillage analysis.
	Sec.6 Table 1	Tank testing load is removed from small tanks typically in engine room, to reflect the scope of strength testing given in Pt.2 Ch.4.
Load combination factor.	Sec.2 Table 10	The factors for a pitch-x and a pitch-z are changed.
	Sec.3 [2]	f_p is updated by replacing f_{fa} with f_R. This applies to all formulas for motions and accelerations.
	Sec.3	Definition of f_R is introduced.
Modifications to structural rules for deck house and superstructure.	Sec.5 [2.2.3] Sec.5 [2.2.4] Sec.5 [3.4.1]	Sec.5 [2.2.3] Clarification of green sea loads on exposed decks from HSM, HSA and FSM load cases has been made. The minimum green sea loads at exposed deck have been updated. Sec.5 [2.2.4] Clarification of green sea loads on exposed decks from BSR, BSP, OST and OSA load cases has been made. In Sec.5 [3.4.1] a clarification of external pressure for end bulkheads of superstructure and deckhouse walls have been made based on principles given in IACS UR S3.

July 2017 edition

This document supersedes the January 2017 edition of DNVGL-RU-SHIP Pt.3 Ch.4.

Changes July 2017, entering into force as from date of publication

Topic	*Reference*	*Description*
Correction of sea pressures for fatigue calculations	Sec.5 [1.4.6]	The formula for f_p is modified.
Design pressure for tank testing is removed for cofferdams	Sec.6 Table 1	Cofferdam is deleted.

January 2017 edition

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.

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, $P_{dl\text{-}d}$, is added.
— Sec.5 [2.3.2]: The formulas for concentrated dynamic force are corrected, the factor f_β 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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