DNV·GL

RULES FOR CLASSIFICATION

Yachts

Edition October 2016
Amended July 2018

Part 3 Hull

Chapter 3 Hull design loads

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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*

CURRENT – CHANGES

This document supersedes the October 2016 edition of DNVGL-RU-YACHT Pt.3 Ch.3.

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.

Amendments July 2018

Editorial corrections have been made.

Amendments January 2018

Editorial corrections have been made.

Amendments July 2017

Editorial corrections have been made.

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

— yacht character definition change, merging of LD (light displacement) and HD (heavy displacement) sailing yachts, separation of multihulls, high speed motor yacht re-directed

— PSF concept waived.

• Sec.1 Introduction

— changed methodology to conventional one excluding partial safety concept

— Sec.1 [1.1.1]: Scope adjusted to re-arranged chapter content.

• Sec.2 Design loads for sailing yachts

— title changed to reflect new chapter set-up

— removed multihull sailing yachts (previous [1.2]) and established new Sec.5

— changed to conventional methodology, excluding partial safety concept

— Sec.2 [2.1]: amended pressure locations

— Sec.2 [2.1.1]: updated nomenclature and c_L definition

— Sec.2 [2.3]: corrected index and amended coefficient.

• Sec.3 Design loads for motor yachts

— title updated to reflect new chapter set-up

— heavy displacement sailing yachts has been removed

— the partial safety factor concept has been waived and a conventional design load concept introduced with the aim to be compatible with both composite and metal scantling determination

— bottom slamming pressure determination has been removed, as it proved obsolete for displacement motor yachts

— definitions for "secondary" design loads have been removed, as they proved to be too detailed

— a panel size factor has been introduced as it is necessary for composite vessels; typically having larger hull panels and still maintain validity for small panels typical in metal construction

— Sec.3 [1.1]: wording has been updated

— Sec.3 Table 1: corrected coefficient

— Sec.3 [3]: symbols adjusted to revised methodology following in Sec.3 [3.1] *Application* and Sec.3 [3.2] *Sea pressures*
— Sec.3 Figure 5: corrected bracket setting for factor k_f
— Sec.3 [3.2.1]: updated equation by including coefficient c_p
— (Previous) [3.2.2]: deleted clause
— Sec.3 [3.2.2]: updated formula for p_{BK}
— Sec.3 [3.3.2]: corrected equation
— Sec.3 [3.4.3]: adjustments made
— (Previous) [3.5]: deleted secondary load definitions.

• Sec.4 Design loads for high speed yachts

— completely revised, re-ordered and important references amended
— high speed motor yachts are now directed completely to DNVGL-RU-HSLC with respect to design loads and metal scantling methodologies

• Sec.5 Design loads for multihull yachts

— this is a new section
— the multihull category has been extracted from previous Sec.2 and Sec.3 for improved user friendliness
— reference for motor multihulls was established towards DNVGL-RU-HSLC
— content for multihulls re-structured and references added.

Editorial corrections

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

CONTENTS

SECTION 1 INTRODUCTION

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

1 General

1.1 Application

1.1.1 Scope

This chapter provides the design load for strength assessments.

The load combinations shall be derived for the design load scenarios which cover the appropriate operating modes of the vessel in question:

Sailing yachts (definition according to Pt.5 Ch.1 Sec.2 [1.1])	Sec.2
Motor yachts (definition according to Pt.5 Ch.2 Sec.2 [1.1])	Sec.3
High speed yachts (definition according to Pt.5 Ch.2 Sec.2 [1.1])	Sec.4
Multihull sailing yachts (definition according to Pt.5 Ch.1 Sec.2 [1.1])	Sec.5
Multihull motor yachts (definition according to Pt.5 Ch.2 Sec.2 [1.1])	Sec.5

Passenger yachts shall be categorized by either of the above mentioned vessel types.

For special hull shapes individual load analyses may be required.

1.1.2 Probability level for strength assessments

In this chapter, the assessments shall be understood as strength assessment for the strength criteria excluding fatigue, for the loads corresponding to the probability level of Q_0 = 10^{-8}.

1.1.3 Dynamic load components

All dynamic load components shall be concurrent values calculated for each dynamic load case.

1.1.4 Loads for strength assessment

The strength assessment shall be undertaken for all design load scenarios (global and local) and the final assessment shall be made on the most onerous strength requirement.

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).

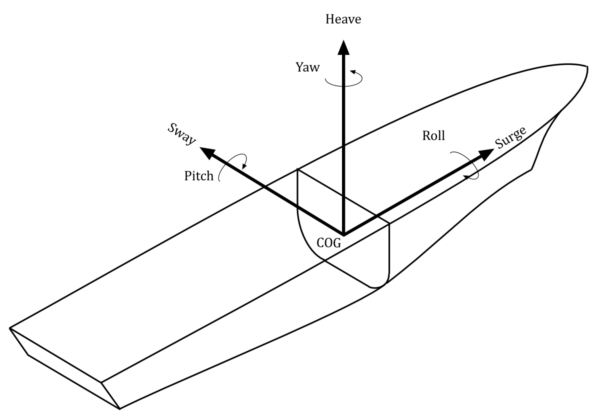

Figure 1 Definition of positive motions

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) according to M_Y
- the vertical shear forces Q_{SW}, Q_{WV} are positive in the case of downward resulting forces acting aft of the transverse section and upward resulting forces acting forward of the transverse section under consideration according to Q_Z
- 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 according to M_Z
- 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 according to M_X.

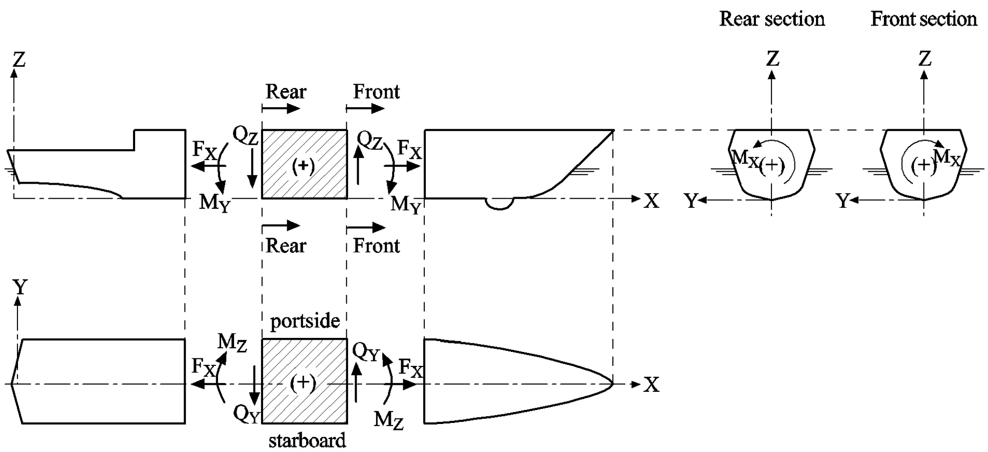

Figure 2 Sign conventions for hull girder shear forces and bending moments

SECTION 2 DESIGN LOADS FOR SAILING YACHTS

1 General

1.1

This section provides the design loads for strength assessments of hull structural elements of monohull sailing yachts. For multihull sailing yachts, design loads are defined in Sec.5.

As per the definition of these rules, the yacht's structure is exposed to quasi static and quasi dynamic sea loads and/or other operational loads.

These loads are called design loads.

There is a distinction between:

— local loads, used to determine scantlings for such as plating, beams, girders and bulkheads, as defined in [2]
— global loads, used to determine scantlings for the hull girder, as defined in [3].

For sailing yachts the design speed v_0 [knots] according to Ch.1 Sec.4 [3.1.10] shall be determined as follows:

$$v_0 = 0.692 \cdot L^{0.333} \cdot c_{vs} \cdot C_c$$

where:

c_{vs} = $\frac{L}{\left(\rho \cdot \Delta^{0.333}\right)}$, where $6.5 \le c_{vs} \le 9.5$

ρ = density of water [to/m^3]

c_c = $0.385 \cdot \frac{(GZ \cdot L)^{0.5}}{\Delta^{0.33}}$, where $c_{cmin} = 0.95$

GZ = is the maximum righting moment lever at heeling angles below 60°, with all stability-increasing devices such as canting keel, water ballast and crew, in their most effective position for upwind sailing, determined at displacement Δ.

2 Lateral design pressures

If not explicitly mentioned (for very large panels or very long structural members), lateral design pressures shall be applied as a constant surface load (for plating and panels) or concentrated as a line load (for beams and girders) and determined at the following locations:

— for panels with longer span in longitudinal direction: center of panel
— for panels with longer span in transverse direction: half of short span from lower edge
— for structural members oriented in longitudinal direction: center of the area supported by the element
— for structural members oriented in transverse direction: half of stiffener spacing from lower edge.

Design pressure distributions can be derived from pressures at individual load points, should this be necessary, e.g. for panels or structural members with large expansion.

2.1 Sea pressures on hull

2.1.1 The pressure p_H [kPa] on the yacht's hull and transom shall be determined as follows:

$$p_H = 10 \cdot T_H \cdot \left(1 - \frac{z}{H}\right) + c_p \cdot c_L \cdot L \cdot \left(1 + \frac{v_0}{3 \cdot \sqrt{L}}\right) \cdot \cos\left(\frac{\alpha}{1.5}\right)$$

v_o = design speed according to [1.1]

for panels:

z = vertical distance between the load point and the moulded base line [m],

c_p = panel size factor as a function of f, see Figure 3, approximated by:

= $0.54\, f^{2} - 1.29\, f + 1.0$

α = $\beta - 20°$, α not smaller than 0°

β = deadrise angle at load point

f = $\frac{(\mathrm{a} - 0.25)}{0.055 \cdot \mathrm{L} + 0.55}$

a = panel’s short span respectively load span of stiffener [m], for the purpose of determining sea pressures not to be taken < 0.25 m or > 1.3 m

for stiffeners and girders:

f = $\frac{(\ell - 0.25)}{0.055 \cdot \mathrm{L} + 0.55}$

ℓ = length of girders or stiffeners between supports [m], for the purpose of determining sea pressures not to be taken < 0.25 m or > 1.3 m

c_L = hull longitudinal distribution factor, see Figure 2

for $x/L < 0$:

$c_L = 0.80$ for $L = 24$ m

$c_L = 0.60$ for $L \geq 48$ m

for $0 \leq x/L \leq 0.65$:

$c_L = 0.80 + 0.615 \cdot x/L$ for $L = 24$ m

$c_L = 0.60 + 0.538 \cdot x/L$ for $L \geq 48$ m

for $x/L \geq 0.65$:

$c_L = 1.20$ for $L = 24$ m

$c_L = 0.95$ for $L \geq 48$ m

2.1.2 In any case the load pH shall not be smaller than:

p_{Hmin} = $10 \cdot H$ [kPa]

for the area of the hull below the full displacement waterline

and:

p_{Hmin} = $5 \cdot H$ [kPa]

for the area of the hull above the full displacement waterline.

2.2 Impact pressures on forward hull bottom

2.2.1 Slamming on forward hull bottom is particularly assumed to occur when the hull is of low canoe body draft and shows large areas of low local deadrise. The below pressure values p_{sl} apply if they are larger than the above defined sea pressures. They shall be applied to the hull bottom in an area where the local deadrise is lower than 50° in upright floatation or below DWL, whichever gives a greater area.

2.2.2 The pressure p_{sl} [kPa] on the yacht's hull shall be determined as follows:

$$P_{sl} = 3\, K_2\, K_3\, K_{WD} \cdot v_0 \cdot v_{sl} \text{ [kPa]}$$

where:

v_{sl} = relative impact velocity [m/s]

= $4 \cdot \frac{H_S}{\sqrt{L}} + 1$

H_S = relevant critical significant wave height [m]

= $\frac{L^{1.333}}{36}$

K_2 = factor accounting for impact area

= $0.455 - 0.35 \cdot \frac{u^{0.75} - 1.7}{u^{0.75} + 1.7}$

≥ 0.50 for plating

≥ 0.45 secondary supporting, e.g. for stiffeners and beams

≥ 0.35 primary supporting, e.g. for girders, floors and frames

= 0.175 for global strength calculations

u = $100 \cdot (s/S_r)$

s = area in m², supported by the element (plating, stiffener, floor, girder or frame). For plating, the supported area is the spacing between the stiffeners multiplied by their span, without taking more than three times their spacing

S_r = reference area [m²]

= $0.7 \cdot (\Delta/T_H)$

K_3 = factor accounting for shape and deadrise of hull:

= $\frac{100 - \alpha}{70}$

α = mean local deadrise of slamming area, may not be taken smaller than 30°. Slamming is applicable up to α = 50°

K_{WD} = longitudinal bottom slamming distribution factor, see Figure 1

= 0 aft of (LCG-15% L)

= $6.67 \cdot x/L - [(\text{LCG}-0.15L)/0.15L]$ between (LCG-15%) and LCG

= 1.0 forward of 0.6 L.

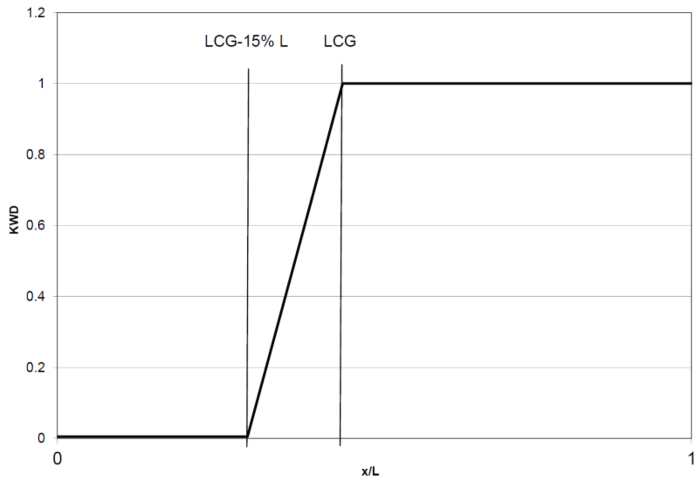

Figure 1 Longitudinal bottom slamming factor K_{WD}

2.3 Loads on weather decks

The design pressure on weather decks shall be determined according to the following equation:

$$p_D = 2.7 \cdot c_D \cdot \sqrt{\frac{L}{T_H + z_{WL}}}$$

$p_{D,\,min}$ = 6.0 kPa

z_{WL} = local height of weather deck above DWL [m]
c_D = deck longitudinal distribution factor
= see Figure 2, c_D is:
= 1.20 for $x/L < 0.05$
= $1.25 - x/L$ for $0.05 \le x/L < 0.25$
= 1.00 for $0.25 \le x/L \le 0.70$
= $2.5\,x/L - 0.75$ for $0.70 < x/L < 0.90$
= 1.50 for $x/L \ge 0.90$

2.4 Load on superstructure and deckhouse walls

2.4.1 Front walls

The design load is:

$$p_{AFW} = 1.5 \cdot p_D \text{ [kPa]}$$

2.4.2 Side walls

The design load is:

$$p_{ASW} = 1.2 \cdot p_D \text{ [kPa]}$$

2.4.3 Aft walls

The design load is:

$$p_{AAW} = 0.8 \cdot p_D \text{ [kPa]}$$

2.5 Loads on superstructure decks

The load on decks of superstructures and deckhouses is based on the load on the weather deck according to [2.3] and is defined by the following equation:

$$p_{DA} = p_D \, n \text{ [kPa]}$$

$p_{DA,min}$ = 4.0 kPa

n = $1 - \frac{z - (H - T_H)}{10}$

z = vertical distance of superstructure deck above DWL [m].

2.6 Loads on accommodation decks

The load on accommodation decks can be assumed as:

$$p_L = p_C \cdot c_D \text{ [kPa]}$$

p_C = to be defined by the designer in connection with the owner’s specification

P_{Cmin} = 3.5 kPa

c_D = longitudinal distribution factor according to Figure 2.

2.7 Loads on bulkheads

Bulkheads are subject to in-plane loading by hull and deck lateral design pressures, global shear and torque and local loads and shall cope with these loadings not exceeding allowable stresses and strains. Besides, buckling of bulkheads shall be considered.

In the following paragraphs, lateral pressure loads for bulkheads are defined. Relevant in-plane sea loads were defined in [2.1] through [2.6].

2.8 Collision bulkhead

The design load is:

$$p_{BH} = 11.5 \cdot z_{BH} \text{ [kPa]}$$

z_{BH} = vertical distance from the load centre to the top of the bulkhead or to the highest point in the compartment in [m].

2.9 Other watertight bulkheads

The design load is:

$$p_{BH} = 10.0 \cdot z_{BH} \text{ [kPa]}$$

2.10 Loads on tank structures

For outer boundary plating the design load is:

$$p_T = 10.0 \cdot z_T \text{ [kPa]}$$

z_T = vertical distance from the load centre to the top of the tank overflow in [m], this also needs to be considered in heeled situation

= not to be taken less than 2.0 m.

For tank baffles:

Without further proof, a default design pressure of 20 kPa shall be adopted. The Society can assist with separate guidance for more refined set of pressures upon request.

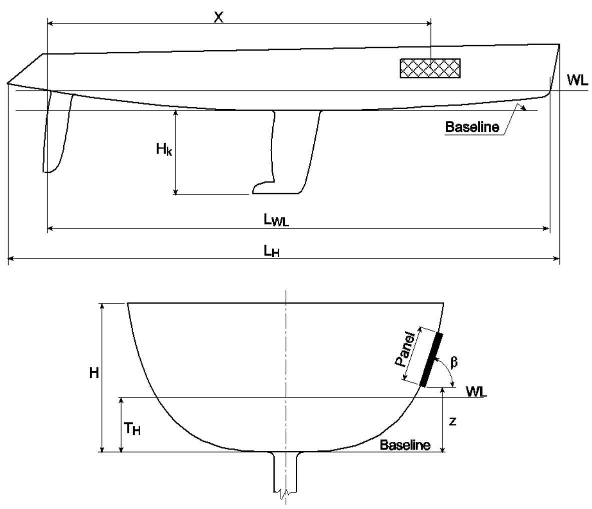

Figure 2 Characteristic parameters for panels of the yacht's hull

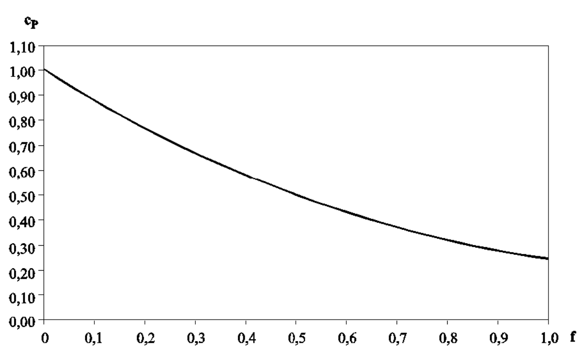

Figure 3 Panel size factor c_p

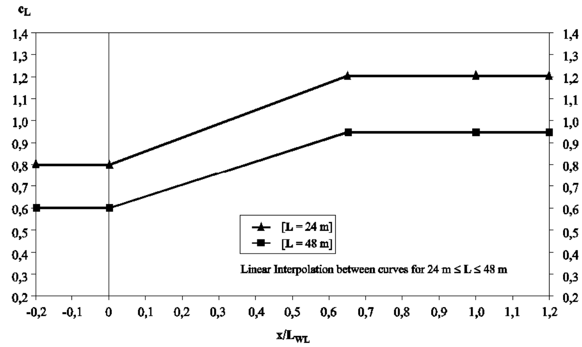

Figure 4 Hull longitudinal distribution factor c_L

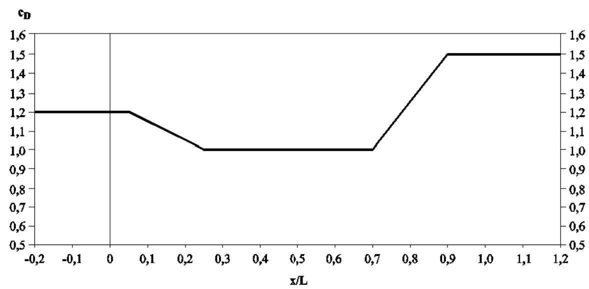

Figure 5 Deck longitudinal distribution factor c_D

3 Global loads

3.1 General

3.1.1 Global loads are considered loads acting on the global hull girder without the consideration of local load introduction.

3.1.2 Global loads are considered to arise through sea loads and through the rig attachments.

3.2 Load cases

For yachts it is considered sufficient to superimpose two load cases:

3.2.1 Rig loads from headstay/backstay.

The maximum working loads of the different headstays shall be used to create a global shear force and bending moment forward of the mast frame, reducing to zero at the stern aft of the mast frame. See Figure 3 and Figure 4.

3.2.2 For yachts with a length L of less than ca. 30 m: Pressure loads from slamming of forward hull bottom.

Pertinent slamming pressure loads shall be determined according to [2.2], using a K_2 of 0.175. The pressures shalll be applied across the total area designated as slamming area. This way, a shear force and bending moment distribution forward of $0.5 \cdot L$ is created.

Aft of 0.5 · *L*, both distributions are reflected, see Figure 3 and Figure 4.

The total slamming force integrated over the whole slamming area needs not to be greater than 4-times the weight force equivalent to the yacht's displacement according to Ch.1 Sec.4 [3.1.10]. For this purpose the factor K_2 can be reduced accordingly.

3.2.3 For yachts of a length greater than ca 30 m:

In addition to [3.2.2] a global static strength analysis shall be carried out with the hull subjected to hydrostatic buoyancy forces excited through a design wave with a wave length of *L* and a wave height of *L*/10 and considering the vessel's self weight distribution at a vertical design acceleration of 1 g. Load cases with the wave crest at different longitudinal positions shall be calculated, with rotational accelerations to balance a structural model if necessary.

3.2.4 The above load values shall be combined and used to check global hull sections at different longitudinal stations. Allowable stresses/strains defined in relevant sections shall not be exceeded. Beside the static strength analysis, a buckling analysis shall be performed to make sure that deck buckling will not be critical.

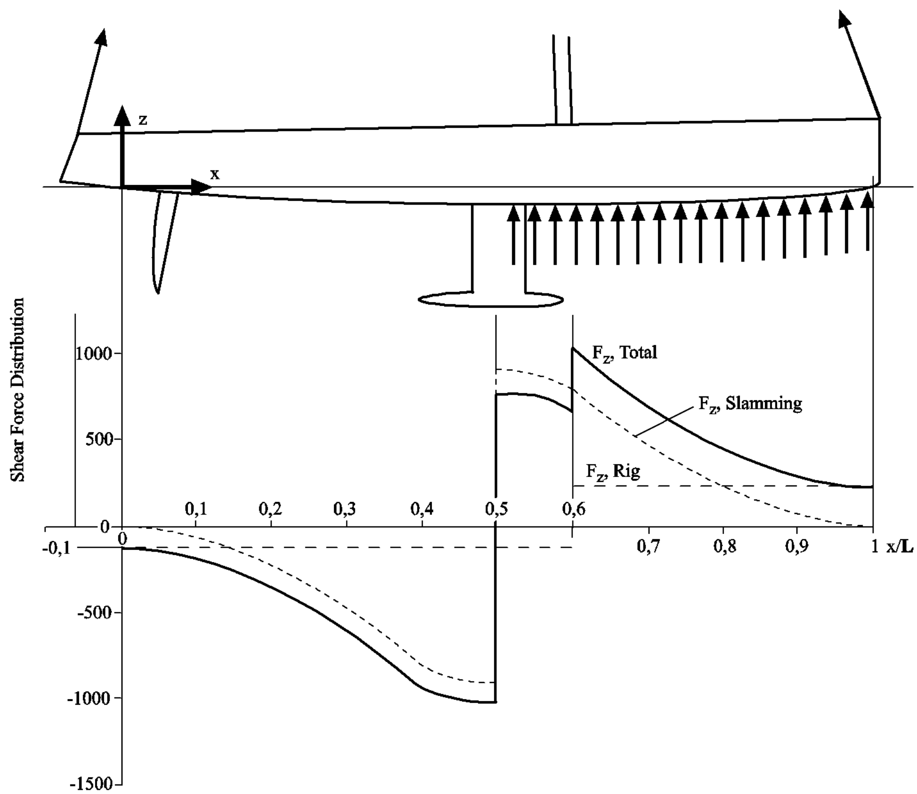

Figure 6 Shear force distribution

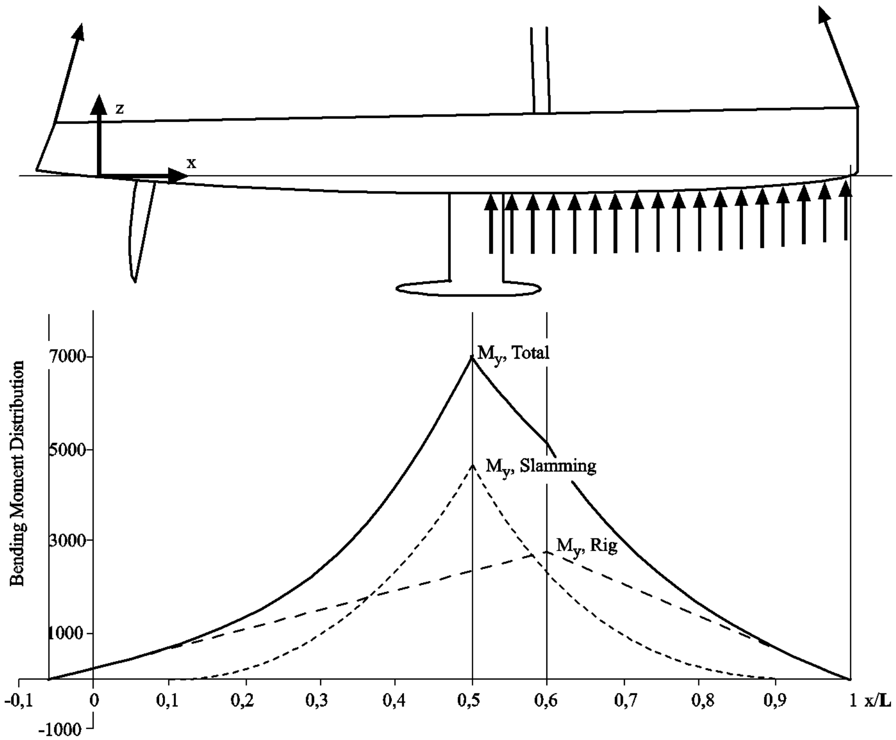

Figure 7 Bending moment distribution

SECTION 3 DESIGN LOADS FOR MOTOR YACHTS

1 Introduction

Symbols

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

c_0 = wave coefficient

= $\left(\frac{L}{25} + 4.1\right) \cdot c_{RW}$ for L < 90 m

= $\left[10.75 - \left(\frac{300 - L}{100}\right)^{1.5}\right] \cdot c_{RW}$

for 90 ≤ L < 300 m

c_v = velocity coefficient

= $\sqrt[3]{\frac{v_0}{1.6 \cdot \sqrt{L}}} \geq 1$ with $1.6 \cdot \sqrt{L} \geq 14$

c_{RW} = service range coefficient

c_{RW} = 1.0 for unlimited service range and **R0**

= 0.90 for restricted service area **R1**

= 0.75 for restricted service area **R3**

= 0.60 for restricted service area **RE**

for other restricted service to be determined on a case by case basis, see also Pt.1 Ch.2 Sec.5

f_Q = probability factor which shall be determined for a straight-line spectrum of seaway-induced stress ranges and for a design life n ≥ 25 years.

The factor may be reduced, if accepted by the Society.

If applicable, the probability level Q is given in the corresponding equations

= $\frac{\log\left(\frac{25}{n} \cdot Q\right)}{\log Q_0}$

= 1.0 in general

n = life time [years]

≥ 25

Q_0 = 10^{-8} probability level, reference value

Q = 10^{-8} in general, if not otherwise specified

a_0 = acceleration parameter, to be taken as:

$$a_0 = \frac{c_0 \cdot c_B}{L^2}\left(0.6 \cdot v_0 + 2.3 \cdot \sqrt{L}\right)^2$$

k_v = distribution factor, see also Figure 1

= 1.8 – (8/3)·(x/L) for x/L < 0.3

= 1.0 for 0.3 ≤ x/L ≤ 0.6

= 5.5 (x/L) – 2.3 for x/L > 0.6

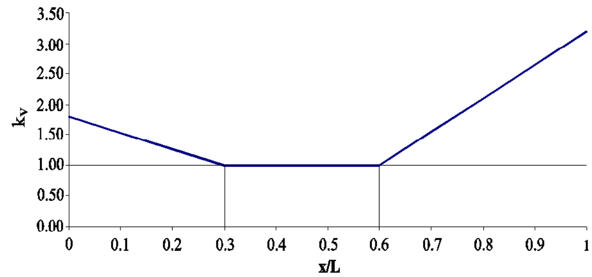

Figure 1 Distribution factor k_v

f_Q = probability factor
Q = 10^{-8} for fixed elements such as masts, etc.
= 10^{-6} for ship safety equipment
= 10^{-5} for loose equipment, content of tanks, deck loads, etc.

1.1 General

This section provides the design loads for strength assessments of hull structural elements of monohull motor yachts, excluding high speed motor yachts. For high speed yachts, design loads are defined in Sec.4. For multihull yachts, design loads are defined in Sec.5.

1.2 Accelerations for dynamic load cases

1.2.1 General

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

The accelerations to be applied for the dynamic load cases are given for each direction in [1.2.2] to [1.2.4].

1.2.2 Longitudinal acceleration

The longitudinal acceleration at any position for each dynamic load case, in g, shall be taken not less than:

$$a_x = 5.8 \cdot a_0 \cdot (z/L) \cdot f_Q \text{ but not less than } 0.3 \cdot f_Q$$

1.2.3 Transverse acceleration

The transverse acceleration at any position for each dynamic load case, in g, shall be taken not less than:

$$a_{y1} = 0.35\left(1 + k_v \cdot a_0\right) f_Q$$

$$a_{y2} = c_0 \frac{z}{B_W^2} f_Q$$

a_y = max (a_{y1}, a_{y2}, 0.5).

1.2.4 Vertical acceleration

The vertical acceleration at any position for each dynamic load case, in g, shall be taken not less than:

$$a_z = a_0 \cdot k_v \cdot f_Q$$

2 Hull girder loads

Symbols

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

M_{SW} = maximum and minimum vertical still water bending moment in seagoing operation at the hull transverse section being considered

= $M_{SW,max}$ for maximum (hogging) still water bending moment, in MNm

$M_{SW,min}$ for minimum (sagging) still water bending moment, in MNm

M_{SWf} = maximum and minimum vertical still water bending moment for damaged/flooded condition, in MNm, at the hull transverse section being considered. If required, the most severe levels of vertical still water bending moments shall be selected from those cases of flooding used in the damage stability calculations

M_{WV} = vertical wave bending moment in seagoing operation, in MNm, at the hull transverse section being considered

= $M_{WV,h}$ for hogging condition, in MNm

$M_{WV,s}$ for sagging condition, in MNm

M_{WVf} = vertical wave bending moment in damaged condition, in MNm, at the hull transverse section being considered. If required, the most severe levels of vertical still water bending moments shall be selected from those cases of flooding used in the damage stability calculations

= M_{WV} with c_V = 1.0

M_{WH} = horizontal wave bending moment, in MNm, at the hull transverse section being considered

M_{WT} = torsional wave bending moment, in MNm, at the hull transverse section being considered

Q_{SW} = positive or negative vertical still water shear force in seagoing operation, in MN, at the hull transverse section being considered

Q_{SWf} = positive or negative vertical still water shear force for damaged/flooded condition, in MN, at the hull transverse section being considered. If required, the most severe levels of vertical still water shear forces shall be selected from those cases of flooding used in the damage stability calculations.

Q_{WV} = positive or negative vertical wave shear force in seagoing operation, in MN, at the hull transverse section being considered

= $M_{WV,h}$ for hogging condition, in MNm

$M_{WV,s}$ for sagging condition, in MNm

Q_{WVf} = positive or negative vertical wave shear force for damaged/flooded condition, in MN, at the hull transverse section being considered. If required, the most severe levels of vertical still water shear forces shall be selected from those cases of flooding used in the damage stability calculations

= Q_{WV} with c_V = 1.0

Q_{WH} = horizontal wave shear force, in MN, at the hull transverse section being considered.

2.1 Application

2.1.1 This subsection provides the hull girder bending moments and shear forces for strength assessments of longitudinal hull girder structural members of monohull motor yachts, excluding high speed motor yachts.

For high speed yachts, design loads are defined in Sec.4.

For multihull yachts, design loads are defined in Sec.5.

2.1.2 Where deemed necessary, alternative direct calculation of dynamic hull girder loads as well as their distribution over the ship's length by approved calculation procedures can be required by the Society. Such calculation procedures shall take into account the ship's motions in a natural seaway according to [2.4].

2.1.3 For ships with large deck openings, the horizontal bending moments and shear forces shall be considered in addition.

2.1.4 Where deemed necessary, loads due to torsion of the ship's hull shall be taken into account.

2.2 Vertical still water hull girder loads

2.2.1 General

In general, the envisaged loading and ballast, based on amount of bunker, fresh water and stores at departure and arrival, shall be considered for the still water bending moment M_{SW} and shear force Q_{SW} calculations.

Ch.10 defines a series of load cases for stability considerations of the undamaged ship. The most critical of these cases form the basis for the longitudinal strength calculations for intact conditions.

If a proven damage stability is required, the longitudinal strength of the flooded ship shall be investigated. For these cases it shall be understood that the hull girder strength of the damaged ship is not (significantly) reduced.

The designer shall provide the permissible still water bending moments and shear forces.

The permissible still water hull girder loads shall be given at points of local maxima for the design loading conditions (i.e. tank loads). 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 and the permissible hull girder shear forces are at least 10% above the maximum still water shear force from the considered loading condition, to account for growth and design margins during the design and construction phase of the ship. The designer is responsible for not exceeding the permissible still water hull girder loads for all seagoing and docking conditions.

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

2.2.2 Vertical still water bending moment

The permissible vertical still water bending moments, $M_{SW,max}$ and $M_{SW,min}$ 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
— the most severe still water bending moments, in hogging and sagging conditions, respectively, for the docking conditions.

2.2.3 Vertical still water shear force

The permissible vertical still water shear forces Q_{SW} at any longitudinal position shall envelop:

— the most severe still water shear forces calculated, positive or negative, for the seagoing loading conditions
— the most severe still water shear forces calculated, positive or negative, for the docking conditions.

2.3 Rule dynamic hull girder loads

2.3.1 Vertical wave bending moments

The vertical wave bending moments M_{WV} at any longitudinal position for hogging and sagging condition, in MNm, to be taken as:

$$M_{WV} = 0.24 \cdot 10^{-3} \cdot L^2 \cdot B_W \cdot \sqrt{c_B} \cdot c_0 \cdot c_v \cdot k_M \quad (1)$$

k_M = distribution factor, see Table 1 and Figure 2.

Table 1 Distribution factor k_M

Range	*Hogging*	*Sagging*
$0 \le x/L < 0.4$	$2.25 \cdot \sqrt{C_B} \cdot x/L$	$-0.02 - 2.45 \cdot x/L$
$0.4 \le x/L < 0.6$	$0.90 \cdot \sqrt{C_B}$	-1
$0.6 \le x/L \le 1$	$\left[0.9 - 2.25\left(x/L - 0.6\right)\right] \cdot \sqrt{C_B}$	$-1 + 2.375(x/L - 0.6)$

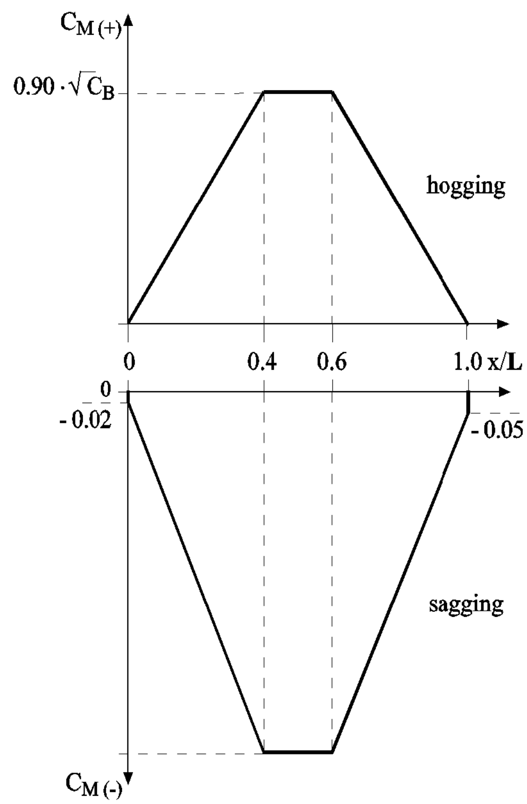

Figure 2 Distribution factor k_M over the ship's length

2.3.2 Vertical wave shear forces

The vertical wave shear forces Q_{WV} at any longitudinal position for hogging and sagging condition, in MN, to be taken as:

$$Q_{WV} = 1.0 \cdot 10^{-3} \cdot L \cdot B \cdot \sqrt{c_b} \cdot c_0 \cdot c_v \cdot k_Q$$

k_Q = distribution factor, see Table 2 and Figure 2.

Table 2 Distribution factor k_Q

Range	*Positive shear forces*	*Negative shear forces*
$0 \leq \frac{x}{\mathbf{L}} < 0.10$	$8.80 \cdot \sqrt{C_B} \cdot \frac{x}{\mathbf{L}}$	$-0.10 - 8.50 \cdot \frac{x}{\mathbf{L}}$
$0.10 \leq \frac{x}{\mathbf{L}} < 0.30$	$0.88 \cdot \sqrt{C_B}$	-0.95
$0.30 \leq \frac{x}{\mathbf{L}} < 0.45$	$2.64 \cdot \sqrt{C_B} - 0.9 - \frac{x}{\mathbf{L}} \cdot \left(\frac{88}{15} \cdot \sqrt{C_B} - 3\right)$	$-1.95 + \frac{10}{3} \cdot \frac{x}{\mathbf{L}}$
$0.45 \leq \frac{x}{\mathbf{L}} < 0.50$	0.45	-0.45
$0.50 \leq \frac{x}{\mathbf{L}} < 0.65$	$\frac{61}{15} \cdot \frac{x}{\mathbf{L}} - \frac{19}{12}$	$-1.95 - \frac{x}{\mathbf{L}} \cdot \left(6.4 \cdot \sqrt{C_B} - 3\right) + 3.2 \cdot \sqrt{C_B}$
$0.65 \leq \frac{x}{\mathbf{L}} < 0.75$	1.06	$-0.96 \cdot \sqrt{C_B}$
$0.75 \leq \frac{x}{\mathbf{L}} \leq 1.0$	$3.64 - 3.44 \cdot \frac{x}{\mathbf{L}}$	$-3.84 \cdot \sqrt{C_B} \cdot \left(1 - \frac{x}{\mathbf{L}}\right)$

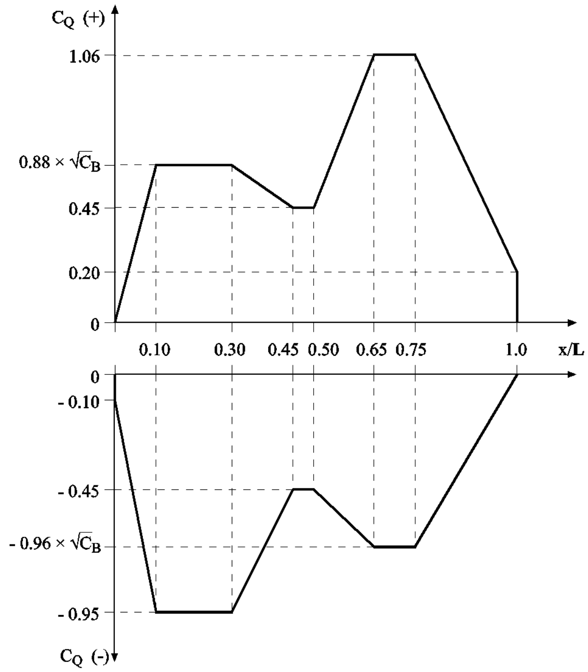

Figure 3 Distribution factor c_Q over the ship's length

2.3.3 Horizontal wave bending moment

The horizontal wave bending moments M_{WH} at any longitudinal position, in MNm, shall be taken as:

$$M_{WH} = 0.32 \cdot L \cdot Q_{WH\max} \cdot k_M \text{ [MNm]}$$

k_M = absolute value of the distribution factor in sagging condition, see Table 1 and Figure 2.

2.3.4 Horizontal wave shear force

The horizontal wave shear force Q_{WH} at any longitudinal position, in MN, shall be taken as:

$$Q_{WH} = Q_{WH\max} \cdot k_{QH} \text{ [MN]}$$

$$Q_{WH\max} = 1.25 \cdot 10^{-3} \cdot \sqrt{L \cdot T} \cdot B_W \cdot c_0$$

k_{QH} = distribution factor, see Table 3 and Figure 4.

Table 3 Distribution factor k_{QH}

Range	k_{QH}
$0 \leq x/L < 0.1$	$0.4 + 6 \cdot x/L$
$0.1 \leq x/L < 0.3$	1
$0.3 \leq x/L < 0.4$	$1.0 - 5 \cdot (x/L - 0.3)$
$0.4 \leq x/L < 0.6$	0.5

Range	k_{QH}
$0.6 \leq x/L < 0.7$	$0.5 + 5 \cdot (x/L - 0.6)$
$0.7 \leq x/L < 0.8$	1.0
$0.8 \leq x/L \leq 1.0$	$1.0 - 4.25 \cdot (x/L - 0.8)$

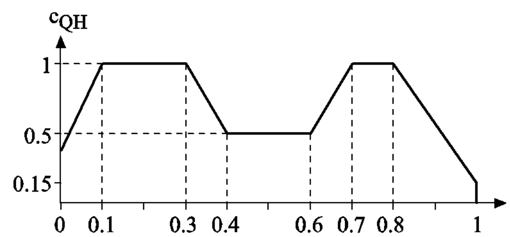

Figure 4 Distribution factor k_{QH} over the ship's length

2.3.5 Wave torsional moment

Effects of the hull girder torsion moment M_{WT} shall be considered if deemed necessary.

2.4 Direct calculation of dynamic hull girder loads

Wave-induced hull girder loads may be determined by direct calculation corresponding to a probability level of $Q_0 = 10^{-8}$ alternatively to the rules loads given in this section. These hull girder loads shall be based on the wave scatter diagram of the North Atlantic, presented in Table 4, if no otherwise specified. Deviations will be included in the annex of class certificate.

As a basis for direct calculation of design values, weight distributions according to applicable load cases defined in [2] shall be used.

In principle, the estimated representative mass distributions for the defined load cases will be the average of the mass distributions that result in the highest and the lowest still water vertical bending moment. This representative mass distribution leads to an average displacement and an average vertical still water bending moment, M_{SW}.

Similar direct calculations of weight distributions for the damaged and/or flooded conditions can be required by the Society shall be performed according to [2.3]. The corresponding representative mass distribution yields an average displacement and an average still water bending moment for the flooded ship, $M_{SWf.}$

Analyses of the ship in harmonic waves shall be executed by direct computational methods that evaluate response operators of wave-induced vertical bending moments and vertical shear forces. Using an adequate nonlinear correction procedure that accounts for a realistic wave breaking criterion, the wave contour along the ship's side shall be determined for relevant harmonic waves with selected wave heights and phase positions. Hydrodynamic pressures shall be extrapolated up to the wave contour.

Hydrodynamic calculations shall be performed for a ship speed of half of the expected maximum, continuous ahead speed in calm water, v_0, shall be assumed.

After completing the nonlinear correction, forces acting on the ship, including inertial forces, generally are not in balance. Equilibrium can be achieved by resolving the motion equations, resulting in nonlinearly corrected response values, e.g., bending moments. Repeating this procedure for different wave periods and wave headings yields nonlinearly corrected (pseudo) response amplitude operators that depend on wave height.

Depending on the considered phase location, different transfer functions result for the sagging and hogging conditions.

Bending moments and shear forces shall be evaluated according to stochastic methods for linear systems. For the stationary seaways, a $\cos^2$ - distribution of wave energy in the main wave encounter direction shall be assumed. The seaways' main wave headings relative to the ship shall be considered as equally distributed. Wave heights (H) used to obtain the wave amplitude dependent (pseudo) transfer functions shall be taken as equal to the significant wave height (H_S)of the corresponding natural seaway (i.e. $H = H_S$).

Calculated long-term values of bending moments and shear forces shall be based on relevant long-term wave statistics as defined by, e.g. the authority. If no data are specified, the wave scatter diagram of the North Atlantic, presented in Table 4, shall be applied. This table lists probabilities of occurrence of sea states identified by the significant wave height H_S [m] and the zero up-crossing period T [s].

The number of load cycles for long-term values shall be estimated according to the operational profile of the ship. If no information is available, $5 \cdot 10^7$ cycles shall be assumed. This considers a lifetime of 25 years with 230 days per year at sea in the North Atlantic.

Total values of vertical bending moments and vertical shear forces result from the superposition of their long-term values with additional slamming loads caused by wave impact in the ship's forebody region. This can be evaluated by multiplication the calculated vertical wave bending moment or shear force, respectively in sagging condition with the distribution factor c_{MSL} or c_{QSL}, respectively.

$$
\begin{aligned}
c_{MSL} &= 1.25 - 0.4\,(x/L) \text{ for } 0 \le x/L < 0.25 \\
&= 1.15 \text{ for } 0.25 \le x/L < 0.5 \\
&= 0.79 + 0.72 \cdot (x/L) \text{ for } 0.5 \le x/L < 0.75 \\
&= 1.12 + 0.28 \cdot (x/L) \text{ for } 0.75 \le x/L < 1.0 \\
c_{QSL} &= 1.0 + 2.5 \cdot (x/L) \text{ for } 0 \le x/L < 0.1 \\
&= 1.25 \text{ for } 0.1 \le x/L < 0.3 \\
&= 1.75 - (5/3)\cdot(x/L) \text{ for } 0.3 \le x/L < 0.45 \\
&= 1.0 \text{ for } 0.45 \le x/L < 0.5 \\
&= (1/6) + (5/3)\cdot(x/L) \text{ for } 0.5 \le x/L < 0.65 \\
&= 1.25 \text{ for } 0.65 \le x/L < 0.75 \\
&= 2 - (x/L) \text{ for } 0.75 \le x/L < 1.0
\end{aligned}
$$

Where deemed necessary, direct calculations described herein shall include loads caused by horizontal bending and torsion of the ship's hull.

Table 4 Wave scatter diagram

	Wave upcrossing period T [s]							
H_s [m]	*3.5*	*4.5*	*5.5*	*6.5*	*7.5*	*8.5*	*9.5*	*10.5*
0.5	1.300E-5	1.337E-3	8.656E-3	1.186E-2	6.342E-3	1.863E-3	3.690E-4	5.600E-5
1.5	0.000E+0	2.930E-4	9.860E-3	4.976E-2	7.738E-2	5.570E-2	2.376E-2	7.035E-3
2.5	0.000E+0	2.200E-5	1.975E-3	2.159E-2	6.230E-2	7.450E-2	4.860E-2	2.066E-2
3.5	0.000E+0	2.000E-6	3.490E-4	6.955E-3	3.227E-2	5.675E-2	5.099E-2	2.838E-2
4.5	0.000E+0	0.000E+0	6.000E-5	1.961E-3	1.354E-2	3.288E-2	3.857E-2	2.686E-2
5.5	0.000E+0	0.000E+0	1.000E-5	5.100E-4	4.984E-3	1.603E-2	2.373E-2	2.008E-2

Wave upcrossing period T [s]								
H_s [m]	*3.5*	*4.5*	*5.5*	*6.5*	*7.5*	*8.5*	*9.5*	*10.5*
6.5	0.000E+0	0.000E+0	2.000E-6	1.260E-4	1.670E-3	6.903E-3	1.258E-2	1.269E-2
7.5	0.000E+0	0.000E+0	0.000E+0	3.000E-5	5.210E-4	2.701E-3	5.944E-3	7.032E-3
8.5	0.000E+0	0.000E+0	0.000E+0	7.000E-6	1.540E-4	9.790E-4	2.559E-3	3.506E-3
9.5	0.000E+0	0.000E+0	0.000E+0	2.000E-6	4.300E-5	3.320E-4	1.019E-3	1.599E-3
10.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	1.200E-5	1.070E-4	3.790E-4	6.750E-4
11.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	3.000E-6	3.300E-5	1.330E-4	2.660E-4
12.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	1.000E-6	1.000E-5	4.400E-5	9.900E-5
13.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	3.000E-6	1.400E-5	3.500E-5
14.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	1.000E-6	4.000E-6	1.200E-5
15.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	1.000E-6	4.000E-6
16.5	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	1.000E-6

Wave upcrossing period T [s]								
H_s [m]	*11.5*	*12.5*	*13.5*	*14.5*	*15.5*	*16.5*	*17.5*	*18.5*
0.5	7.000E-6	1.000E-6	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
1.5	1.607E-3	3.050E-4	5.100E-5	8.000E-6	1.000E-6	0.000E+0	0.000E+0	0.000E+0
2.5	6.445E-3	1.602E-3	3.370E-4	6.300E-5	1.100E-5	2.000E-6	0.000E+0	0.000E+0
3.5	1.114E-2	3.377E-3	8.430E-4	1.820E-4	3.500E-5	6.000E-6	1.000E-6	0.000E+0
4.5	1.275E-2	4.551E-3	1.309E-3	3.190E-4	6.900E-5	1.300E-5	2.000E-6	0.000E+0
5.5	1.126E-2	4.636E-3	1.509E-3	4.100E-4	9.700E-5	2.100E-5	4.000E-6	1.000E-6
6.5	8.259E-3	3.868E-3	1.408E-3	4.220E-4	1.090E-4	2.500E-5	5.000E-6	1.000E-6
7.5	5.249E-3	2.767E-3	1.117E-3	3.670E-4	1.020E-4	2.500E-5	6.000E-6	1.000E-6
8.5	2.969E-3	1.746E-3	7.760E-4	2.770E-4	8.400E-5	2.200E5	5.000E-6	1.000E-6
9.5	1.522E-3	9.920E-4	4.830E-4	1.870E-4	6.100E-5	1.700E-5	4.000E-6	1.000E-6
10.5	7.170E-4	5.150E-4	2.730E-4	1.140E-4	4.000E-5	1.200E-5	3.000E-6	1.000E-6
11.5	3.140E-4	2.470E-4	1.420E-4	6.400E-5	2.400E-5	7.000E-6	2.000E-6	1.000E-6
12.5	1.280E-4	1.100E-4	6.800E-5	3.300E-5	1.300E-5	4.000E-6	1.000E-6	0.000E+0
13.5	5.000E-5	4.600E-5	3.100E-5	1.600E-5	7.000E-6	2.000E-6	1.000E-6	0.000E+0
14.5	1.800E-5	1.800E-5	1.300E-5	7.000E-6	3.000E-6	1.000E-6	0.000E+0	0.000E+0
15.5	6.000E-6	7.000E-6	5.000E-6	3.000E-6	1.000E-6	1.000E-6	0.000E+0	0.000E+0
16.5	2.000E-6	2.000E-6	2.000E-6	1.000E-6	1.000E-6	0.000E+0	0.000E+0	0.000E+0

3 Local design loads

Symbols

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

p_S	=	design pressure on hull and weather exposed structures
p_{BK}	=	hydrodynamic design pressure on bilge keel
p_{T1}	=	design pressure for tanks
p_{T2}	=	design pressure for tanks
p_{T3}	=	design load chain locker
p_{WT}	=	design pressure on watertight partitions
Δp	=	additional pressure component, in bar, created by overflow systems
p_D	=	pressure on deck
F_E	=	single point force
F_{Imp}	=	helicopter landing impact for one wheel or skid
$MTOW$	=	maximum take-off weight, in t, of the helicopter, including deadweight, crew, fuel, cargo, etc.
W	=	axle load of a vehicle in t
k_F	=	distribution factor according to Table 5
p_0	=	basic external dynamic load, in kPa
	=	$5.0 \cdot \sqrt{C_B} \cdot c_0 \cdot c_v \cdot f_Q$
f_Q	=	probability factor for $Q = 10^{-8}$
n	=	number of wheels or twin wheels per axle
n_1	=	ship's surface coefficients as defined in Table 6
n_2	=	ship's surface coefficients as defined in Table 6
n_3	=	ship's surface coefficients as defined in Table 6
c_α	=	flare factor
	=	$0.4/(1.2 - 1.09 \cdot \sin \alpha)$ in general ≥ 1.0 for bow doors and stem structures
	=	0 for decks and walls
α	=	flare angle, in degree, see Figure 5
φ	=	design heeling angle, in degree, for tanks
	=	$\arctan(f_{bk} \cdot H/B)$ in general
f_{bk}	=	0.5 for ships with bilge keel without fins and stabilizers
	=	0.6 for ships without bilge keel
b	=	upper breadth of tank, in m
h_1	=	distance, in m, from load centre to tank top
h_2	=	distance, in m, from tank top to top of overflow acc. to Pt.4 Ch.6 Sec.3 [5.1]
	=	not less than 2.5 m or 10 Δp, respectively
h_3	=	distance, in m, from load centre to top of filled space, i.e. top of chain locker pipe etc.
y	=	distance, in m, from load centre to the vertical longitudinal central plane of tank
T_{dam}	=	draught, in m, for the extreme damage waterline above base line. For ships without proven damage stability, the height of the bulkhead deck above baseline shall be used.

For the collision bulkhead, the distance of the upper edge of the collision bulkhead at the ship's side to the base line shall be used.

Table 5 Distribution factor k_F, height factor c_z and factor n_4

Region	*Factor k_F*	*Factor c_Z*	*Factor n_4*
$0 \leq \frac{x}{\mathbf{L}} < 0.25$	$1.0 + \frac{6 + c_\alpha^2}{1 + 3\ C_B} \cdot \left(0.25 - \frac{x}{\mathbf{L}}\right) - c_z \geq 1.0$	$\frac{z - \mathbf{T}}{c_0} - 0.5 \geq 0$	$0.75 + \frac{x}{\mathbf{L}}$
$0.25 \leq \frac{x}{\mathbf{L}} < 0.7$	1.0	--	1.0
$0.7 \leq \frac{x}{\mathbf{L}} < 0.9$	$1.0 + \frac{20 + \left(c_\alpha{}^2 + c_v\right)^2}{C_B} \cdot \left(\frac{x}{\mathbf{L}} - 0.7\right)^2 - c_z \geq 1.0$	$\frac{z - \mathbf{T}}{c_0} - 1.0 \geq 0$	$3.94 - 4.2 \cdot \frac{x}{\mathbf{L}}$
$0.9 \leq \frac{x}{\mathbf{L}} < 1.0$	$1.0 + \frac{1}{25\ C_B} \cdot \left(20 + \left(c_\alpha{}^2 + c_v\right)^2\right) - c_z \geq 1.0$		

Table 6 Definition of n_1, n_2 and n_3

Surface element	*Factor n_1*	*Factor n_2*	*Factor n_3*
Shell	1.0	1.0	1.0
Weather decks	0.25	1.0	1.0
Unprotected front walls	$0.25 \leq 1.0 - \frac{n_4(z - T - 0.02\mathbf{L} - 0.5)}{c_0} \leq 1.0$	$0.3 + 0.7\frac{b'}{B'}$	$2 + \frac{T - z + h_N}{0.02 \cdot \mathbf{L} + 1} \geq 1.0$
Protected front walls and side walls			1.0
Aft end walls			$1.0 - \left(\frac{x}{\mathbf{L}}\right)^2 \geq 0.6$

n_4 = see Table 5

h_N = $0.8 + 0.01\mathbf{L} \leq 2.3$

b' = breadth of superstructure or deckhouse at position considered

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

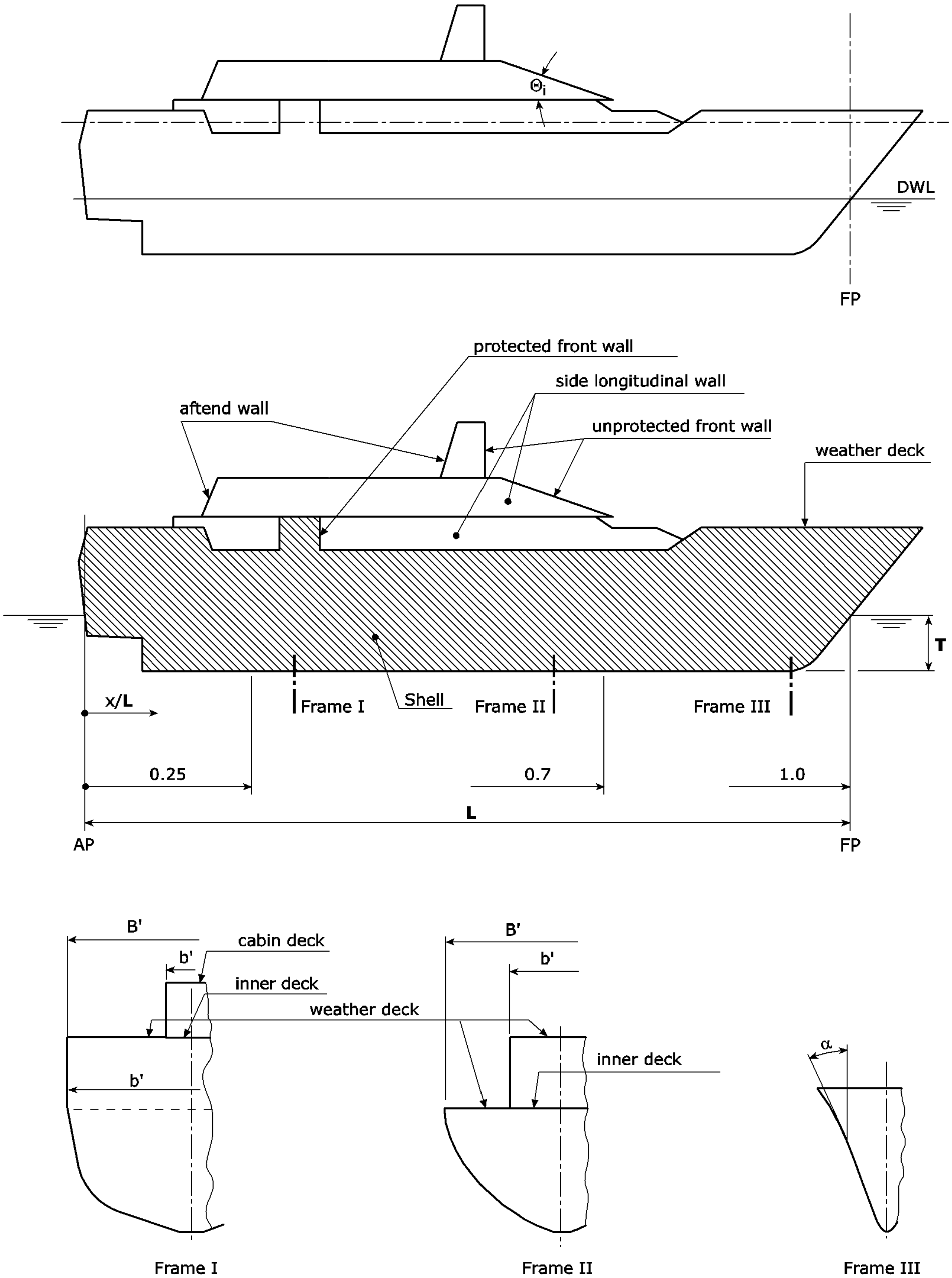

Figure 5 Definition of different parts of the ship's surface exposed to the sea

3.1 Application

3.1.1 This subsection provides specifications for local design loads to determine scantlings of hull structural elements of monohull motor yachts, excluding high speed motor yachts.

For high speed yachts, design loads are defined in Sec.4.

For multihull yachts, design loads are defined in Sec.5.

In general, the design load consists of following components:

p = lateral design pressure [kPa]

= $p_{stat} + p_{dyn}$

F = design force [kN]

= $F_{stat} + F_{dyn}$

= F_{imp}

If not explicitly mentioned, lateral design pressures shall be applied as a constant surface load (for plating and panels) or concentrated as a line load (for beams and girders) and determined at the following locations:

- for panels:
  - with longer span in longitudinal direction: center of panel
  - with longer span in transverse direction: half of short span from lower edge.
- for structural members:
  - for scantling formulas considering trapezoidal load distribution: both end supports (A and B)
  - for scantling formulas considering mean value: half of unsupported length.

Design pressure distributions can be derived from pressures at individual load points, should this be necessary, e.g. for panels or structural members with large expansion.

3.2 Sea pressures

3.2.1 Sea pressures on hull and weather exposed structures

The hydrostatic and hydrodynamic design pressures at any load point, in kPa, on hull and weather exposed structures (Figure 5) shall be taken as:

p_{Sstat} = $10\ (T - z)$ for $z < T$

= 0 for $z \geq T$

p_{Sdyn} = $p_0 \cdot K_F \cdot C_p \cdot \left[1 + \left(\frac{z}{T}\right)^{0.75}\right]$ for $z < T$

= $p_0 \cdot K_F \cdot C_p \cdot \left[0.25 + \frac{1.75}{1 + \frac{z - T}{c_0}}\right] n_1 \cdot n_2 \cdot n_3$ for $z \geq T$

$\geq p_{Smin}$

p_{Smin} = 4.0 kPa for weather decks in general and unprotected front walls

= 2.5 kPa for roofs or cabin decks

= 3.0 kPa for walls, except unprotected front walls

C_p	=	$1.1 - 0.2 \cdot \ell$
	=	1.0 for plates and pillars
		≥ 0.75 for stiffeners (secondary members)
		≥ 0.6 for girders (primary members
ℓ	=	length of girders or stiffeners.

3.2.2 Hydrodynamic pressures on bilge keels

For ships with length L between 50 m and 200 m, the hydrodynamic design pressure p_{BK} on the bilge keels (Figure 6) located between 0.4 L and 0.6 L, in kPa, shall be taken as:

$$p_{BK} = 1.85 \frac{52000 \cdot p}{(L + 240)^{1.1}}$$

For ship lengths below 50 m and above 200 m, the loads on bilge keels shall be specially considered.

Forward of 0.5 L, the slamming design pressure according to [3.2.2] shall also be taken into account.

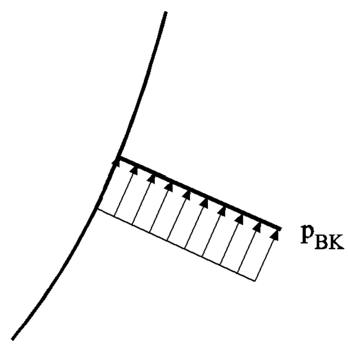

Figure 6 Design load p_{BK} at bilge keel

3.3 Tank and bulkhead pressures

For fuel tanks and ballast tanks connected to an overflow system, the dynamic pressure increases due to overflowing and shall be taken into account in addition to the static pressure. The static pressure corresponds to a pressure height extending up to the highest point of the overflow system.

3.3.1 Design tank pressure p_{T1}

The hydrostatic and dynamic design pressures at any load point of a tank, in kPa, shall be taken as:

p_{T1stat}	=	$\rho \cdot g \cdot h_1 + 100\ \Delta p$ in upright condition
	=	$p \cdot g \cdot h_1 \cdot \cos\varphi + 100\ \Delta p$ in heeled condition
p_{T1dyn}	=	$\rho \cdot g \cdot h_1\ a_Z$ in upright condition
	=	$\rho \cdot g \cdot (0.3 \cdot b + y) \cdot \sin\varphi$ in heeled condition.

3.3.2 Maximum static design pressure p_{T2}

The hydrostatic and dynamic design pressures at any load point of a tank, in kPa, shall be taken as:

$$p_{T2stat} = \rho \cdot g \cdot h_2 + 100\ \Delta p$$

$$p_{T2dyn} = 0$$

3.3.3 Design pressure for filled spaces p_{T3}

The hydrostatic and dynamic design pressures at any load point of filled spaces of moderate size, in kPa, shall be taken as:

$$p_{\mathrm{T3stat}} = \rho \cdot g \cdot h_3$$

$$p_{\mathrm{T3dyn}} = p_{\mathrm{T3stat}} \cdot a_Z$$

3.3.4 Watertight partitions

The hydrostatic and dynamic design pressures at any load point, in kPa, for watertight bulkheads shall be taken as:

$$p_{\mathrm{WTstat}} = \rho \cdot g \cdot (T_{\mathrm{dam}} - z)$$

$$p_{\mathrm{WTdyn}} = \rho \cdot g$$

3.4 Deck loads

3.4.1 Application

The deck loads and concentrated static design forces shall be defined by the designer and are specified in the load plan and/or deck plan.

For the design of landing, parking and hangar decks suitable for helicopter operation, the structure shall be investigated under the most unfavourable parking position of any kind and type of helicopter.

The actual lashing system and tie down forces, defined by the designer are additionally to be considered, if applicable.

For scantling purposes, other loads (distributed loads, snow/ice, etc.) shall be considered simultaneously or separately, depending on the conditions of operation to be expected.

For weather decks the design pressures according to [3.2.1] shall also be taken into account.

3.4.2 Distributed loads

The static pressure due to the distributed load defined by the designer and the dynamic pressure, in kPa, shall not be taken less than:

p_{Dstat} ≥ 3.5 kPa in general

= 8.0 kPa for platforms of machinery decks
= 6.0 kPa for platforms of mooring decks
= 3.5 kPa for accommodation decks
= 3.0 kPa for hangar deck

p_{Ddyn} = $a_Z \cdot p_{\mathrm{Dstat}}$

3.4.3 Single point loads and wheel loads

The wheel load is evenly distributed over the contact area *f*.

Axle and wheel spacing and tyre print dimensions shall be taken into account. In case of narrowly spaced wheels these may be grouped together to one wheel print area.

If the wheel print area *f* is not known, it can be estimated, in m^2 as follows:

f = F_{Estat} / (100 p) for vehicle in general
= 0.3 × 0.3 m^2 for wheels or skids of helicopter

p = specific tyre pressure, in bar.

The static and dynamic design forces, in kN, for wheel loads shall be taken as:

F_{Estat}	=	g W/n for vehicle in general
	=	0.5 g · *MTOW* for wheels or skids of helicopter acting simultaneously with p=2.0 kPa evenly distributed over the entire landing deck (for taking snow or etc. into account)
F_{Edyn}	=	$a_Z \cdot F_{Estat}$
F_{Imp}	=	$1.5 \cdot F_{Estat}$ (at two points simultaneously)
p	=	0.5 kPa (evenly distributed over the entire landing deck)
dead load	=	normal gravity load of structural members
wind loading	=	if unknown, v_W=25 $^m/_s$ shall be used.

Emergency/ crash landing impact combined with following forces:

F_{imp}	=	$2.5 \cdot F_{Estat}$ (at two points simultaneously)
p	=	0.5 kPa (evenly distributed over the entire landing deck)
dead load	=	normal gravity load of structural members
wind loading	=	if unknown, v_W=25 $^m/_s$ shall be used.

SECTION 4 DESIGN LOADS FOR HIGH SPEED MOTOR YACHTS

1 Introduction

This section provides definitions of design loads for strength assessment of hull structural elements for

— high speed motor yachts.

The compilation of the required full set of local and global design loads is done by referencing to methodologies presented in other sections or rules, amended by particular items as defined in this section.

2 General

2.1

A high speed yacht is a yacht capable of maximum speed v_0 equal to or exceeding the design speed v_{HSC} as defined in Pt.5 Ch.2 Sec.1 [1.4].

2.2

For high speed yachts the limit sea state and the design operational conditions as defined for the ship type crew boat according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [1.1] and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [2.1] are applicable.

2.3

Design loads adopted from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.4, shall use:

— the individual parameters and terms from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.1 [3.1] and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.1 [3.2]
— design operational conditions from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [2].

3 High speed motor yachts

3.1 Lateral design pressures

For high speed motor yachts the lateral design pressures according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 are applicable, considering the individual parameter definitions from [2.3] above.

3.2 Hull girder loads

For high speed motor yachts the hull girder loads according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.4 are applicable, considering the individual parameter definitions from [2.3] above.

SECTION 5 DESIGN LOADS FOR MULTIHULL YACHTS

1 Introduction

This section provides definitions loads for strength assessment of hull structural elements for

— multihull yachts.

The compilation of the required full set of local and global design loads is done by referencing to methodologies presented in other sections or rules, amended by particular items as defined in this section.

2 Multihull sailing yachts

2.1 General

For the purpose of calculation the design speed for multihull sailing yachts, the *GZ* value in Sec.2 [1.1] shall be determined using:

$$GZ = \frac{B_{c-c}}{2}$$

$B_{c\text{-}c}$ = breath between hull centres.

2.2 Lateral design pressures

For multihull sailing yachts the lateral design pressures according to Sec.2 [2] are applicable.

2.2.1 For multihull sailing yachts with very slender hulls with wave-piercing ability, all hull design pressures except for slamming pressure shall be superimposed by an individual design head wedge, starting forward of mast with value zero and increasing to a value similar to local freeboard at the bow (this value will be individually assigned by the Society).

An alternative method is to find the potential submersion by setting a negative trim angle of 20° (bow down), taken at a point where the DWL intersects with the mast longitudinal axis.

2.2.2 For multihull sailing yachts the cross deck design pressures shall be determined according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [3.4] (slamming pressure on flat cross structures), but without the minimum pressure defined therein.

Instead, the cross deck design pressures shall not be less than the sea pressures according to Sec.2 [2].

The following parameters apply:

$a_{cg} = 1.0\ g = 9.81\ \mathrm{m/s^2}$

k_t for cross decks: For cats with very slender forward demi hulls, the k_t (longitudinal distribution factor) shall refer to the longitudinal extent of the cross deck, not that of the vessel. I.e. should the cross deck start only 40% *L* aft of the bow, this location is not considered as 0.6 *L*, but as 1.0 *L*.

2.3 Global loads

The global loads shall be determined according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.4 [2] (twin hull loads) for an a_{cg} = 1.0 g = 9.81 m/s^2. Additionally, the rig maximum safe working loads shall be applied according to Sec.2 [3.2.1]. For rigs with no backstay nor running backstay, the contribution through shrouds shall be used instead.

3 Multihull motor yachts

3.1 General

3.1.1 The following directions are valid for multihull motor yachts, where it is considered that those yachts are of high speed or light displacement characteristics. If a yacht is deemed not offering these characteristics, an individual compilation of design loads for the purpose of determining scantlings is required, in agreement with the Society.

3.1.2 For multihull motor yachts with a speed to length ratio $\frac{V}{\sqrt{L}} \geq 3$ the limit sea state and the design operational conditions as defined for the ship type crew boat according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [1.1] and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [2.1] are applicable.

3.1.3 In general, the design loads for multihull motor yachts shall be adopted from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.4, using:

— the individual parameters and terms from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.1 [3.1] and DNVGL-RU-HSLC Pt.3 Ch.1 Sec.1 [3.2]
— design operational conditions from DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 [2].

3.2 Lateral design pressures

For multihull motor yachts the lateral design pressures and forces according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.3 are applicable, considering the individual parameter definitions from [3.1.3], above.

3.3 Global loads

The global loads shall be determined according to DNVGL-RU-HSLC Pt.3 Ch.1 Sec.4, considering the individual parameter definitions from [3.1.3], above.

CHANGES – HISTORIC

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The rules enter into force 1 July 2016.

About DNV GL
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