SECTION 1 HYDRODYNAMIC LOADS

Symbols

C_W : Wave height defined in [1.1.3]

L_W : Wave length, defined in [1.1.3]

X_I : Wave load coefficient, defined in [2.2.1] and in Tab 1

B_W : Breadth at waterline. For catamarans, see Fig 3

ℓ : Distance between internal sideshells of catamaran at waterline, defined in Fig 3

p_s : Sea pressure defined from [2] to [4]

p_{smin} : Minimum pressure on side shell as defined in [2.3]

p_{sumin} : Minimum pressure on superstructure as defined in Tab 3

p_{dmin} : Minimum pressure on deck as defined in [3.1.2].

1 Sea pressure

1.1 General

1.1.1 The local loads induced by the sea pressure on any point of the outside shell are the combined action of the hydrostatic pressure and the pressure induced by waves.

1.1.2 The hydrostatic pressures are calculated with full load condition.

1.1.3 The pressure induced by waves is given as a function of:

- the wave height C_W, in m, equal to:

  $C_W = 10 \log (L_W) - 10$

  without being taken less than 3m, where:

  L_W : Wave length equal to $0,5 (L_{WL} + L_{HULL})$
- a wave load coefficient X_i, defined inTab 1, and depending on the longitudinal location and on the type of yacht.

1.1.4 Bottom area

The bottom area is the part of the hull located below the full load waterline (see Fig 1).

1.1.5 Side shell area

The side shell area is the part of the hull located above the full load waterline.

1.2 Bottom and side shell

1.2.1 Bottom sea pressure for monohull

For monohull, sea pressure on bottom is considered uniform on the bottom area in any transverse section.

1.2.2 Side shell sea pressure for monohull

For monohull, side shell sea pressure are derived from the bottom sea pressure, taking into account the vertical distance z between the calculation point and the full load waterline in the considered transverse area (see Fig 2).

1.2.3 Bottom and side shell sea pressure for catamaran

In case of catamarans, the sea pressure for bottom and side shell are calculated taking account of a vertical distance between load point and base line, as shown on Fig 3.

2 Pressure on bottom and side shell

2.1 General

2.1.1 In any point, the design sea pressure to be taken into account for platings, secondary stiffeners and primary stiffeners is given in [2.2]

Figure 1 : Definition of bottom area for monohulls

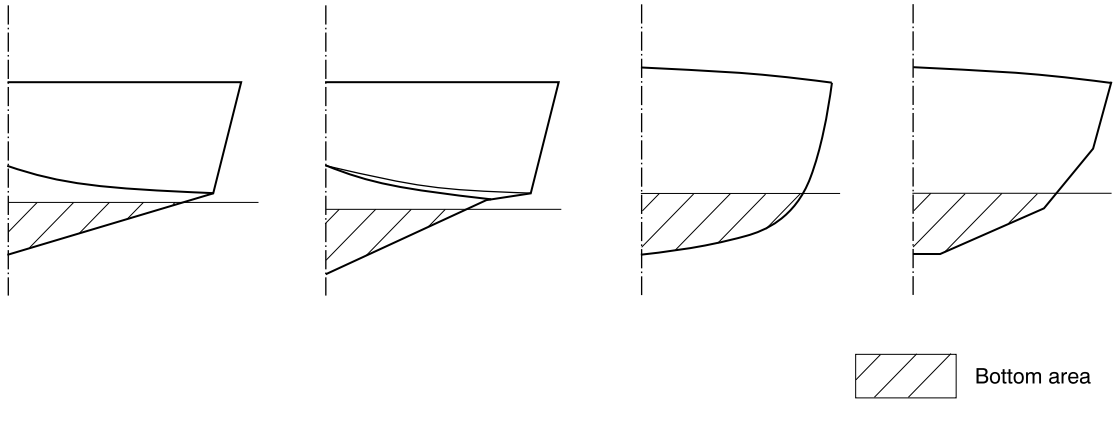


Figure 2 : Vertical distance z for monohull

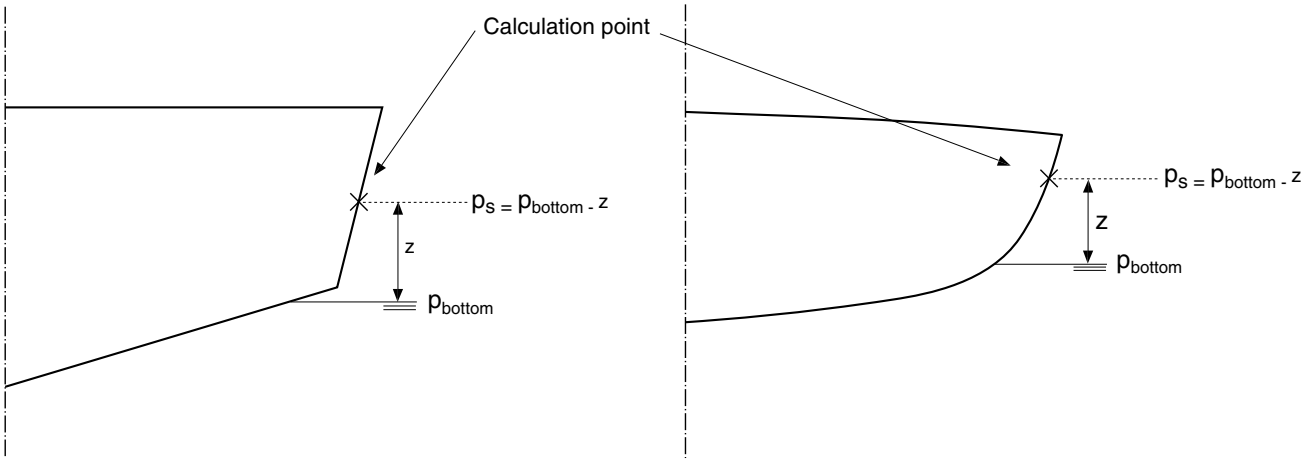
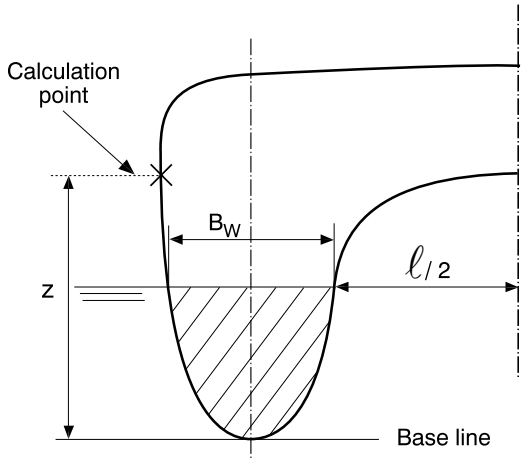


Figure 3 : Vertical distance z for catamarans



2.2 Sea pressure

2.2.1 For all types of yachts, the sea pressure in any point of the bottom and side shell, in kN/m^2, is defined by the following formula:

$$P_S = 9{,}807\, n\left[T + \left(\frac{C_W}{X_I} + h_2\right) - z\right]$$

where:

n : Coefficient depending on the navigation notation, as given in Pt B, Ch 4, Sec 2

T : Full load draught, in m

C_W : Wave height, defined in [1.1.3], in m

X_I : Wave load coefficient shown on Fig 4, and defined in Tab 1

z : Vertical distance from calculation point to the full load waterline (monohull) or to the base line (catamarans). For monohull, bottom pressure is calculated with z = 0

h_2 : Distance in m, equal to:

- for monohull: $h_2 = 0$
- for bottom or external side shell of catamarans: $h_2 = 0$
- for internal side shell of catamaran and inner side of cross deck of catamaran:

$$h_2 = \frac{B_W\left(T + \frac{C_W}{X_I}\right)C_B}{\ell}$$

where:

B_W : Breadth at full load waterline at considered transverse section (see Fig 3)

ℓ : Distance between internal side shells at waterline at considered transverse section, in m, as defined in Fig 3

C_B : Block coefficient defined in Ch 1, Sec 2, [2.1.1].

Table 1 : Wave load coefficients

Type of yachts	Area 4 **(1)** X_4	Area 3 **(1)** X_3	Area 2 **(1)** X_2	Area 1 **(1)** X_1
Monohull motor yacht	2,8	2,2	1,9	1,7
Monohull sailing yacht	2,2	1,9	1,7	1,4
Multihull motor yacht	2,8	2,2	1,9	1,4
Multihull sailing yacht	2,5	2,2	1,7	1,1
(1) See Fig 4 for definition of areas.				

Figure 4 : Load areas and coefficient X_i for the external side shell and bottom sea pressure

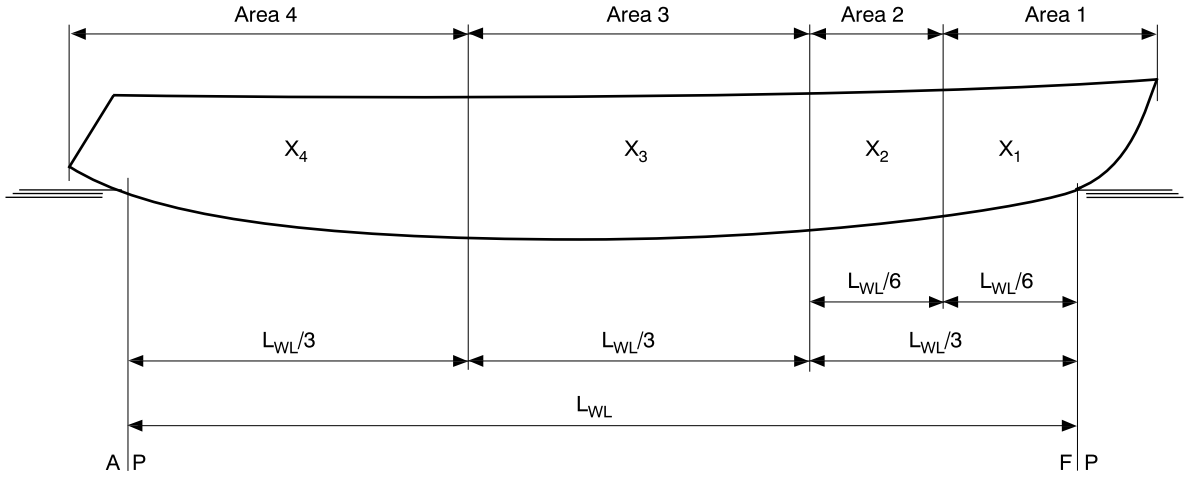
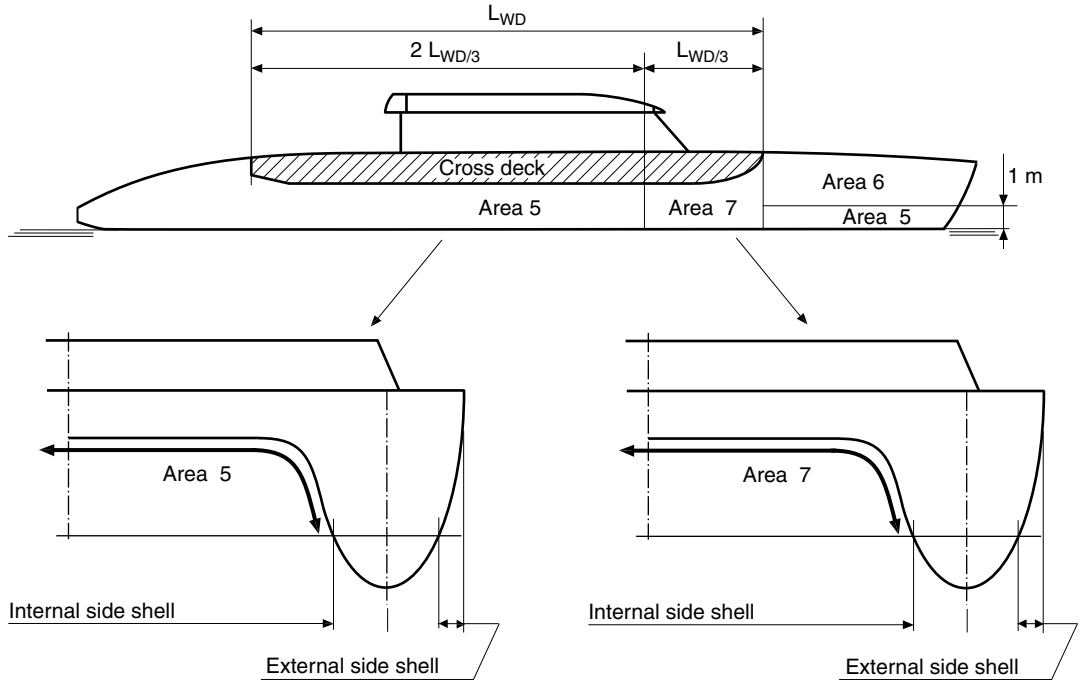


Figure 5 : Load areas for the impact pressure on internal side shell on catamaran



2.3 Impact pressure on side shell

2.3.1 General

The impact pressure given hereafter is to be considered as a minimum pressure on side shell and is to be taken into account only for plating and secondary stiffeners located on side shell area as defined in [1.1.5].

Impact pressure on side shell represents the local wave impact load and is locally distributed like a water column of 0,6 m diameter. The admissible stresses or the safety coefficients to be considered are given in Ch 4, Sec 3.

2.3.2 Monohull

In any point of the side shell of monohull, the impact pressure p_{smin}, in kN/m^2, is to not be less than:

- in areas 1 and 2 as defined in Fig 4 (from fore perpendicular to $L_{WL}/3$ aft of fore perpendicular), between the full load waterline and 1 m above:

  $p_{smin} = 80\ n\ K_2$
- elsewhere:

  $p_{smin} = 50\ n\ K_2$

where:

n : Coefficient depending on the navigation notation, as given in Ch 4, Sec 2

k_2 : $K_2 = 0,455 - \left(0,35 \cdot \dfrac{u^{0,75} - 1,7}{u^{0,75} + 1,7}\right)$

with:

$K_2 \geq 0,50$ for plate panel

$K_2 \geq 0,45$ for stiffener,

and:

$u = 100\ s / S_r$

S_r : reference area, m^2, equal to:

$$S_r = 0,7\frac{\Delta}{T}$$

For catamaran, Δ in the above formula is to be taken as half the craft displacement

s : Surface of the elementary plate panel or surface of the plate panel supported by the stiffener, in m^2

T : Full load draught, in m.

2.3.3 Catamaran

In any point of the external side shell of catamaran, the impact pressure p_{smin}, in kN/m^2, is to not be less than:

- in areas 1 and 2, as defined in Fig 4 (from fore perpendicular to $L_{WL}/3$ aft of fore perpendicular), between the full load waterline and 1 m above: $p_{smin} = 80\ n\ K_2$
- elsewhere, $p_{smin} = 50\ n\ K_2$

where:

n, K_2 : As defined in [2.3.2]

In any point of the internal side shell and the underside of cross deck of catamarans, the impact pressure p_{smin}, in kN/m^2, is to be not less than:

- in area 5 as defined in Fig 5: $p_{smin} = 80\ n\ K_2$
- in area 6 as defined in Fig 5: $p_{smin} = 50\ n\ K_2$
- in area 7 as defined in Fig 5: $p_{smin} = 120\ n\ K_2$

where:

n, K_2 : As defined in [2.3.2].

3 Pressure on decks

3.1 Exposed decks

3.1.1 The sea pressure on any point of exposed deck, in kN/m^2, is to be not less than the greater of the sea pressure given hereafter and the minimum pressure given in [3.1.2]:

$$P_s = (p_0 - z_D 9,807)\varphi_1 n$$

where:

φ_1 : Reduction coefficient depending of the location of the considered deck with respect to the full load waterline:

- $\varphi_1 = 1,00$ for freeboard deck(m), as defined in Ch 2, Sec 2, [2.2.1]
- $\varphi_1 = 0,75$ for the first deck just above the freeboard deck(m), as defined in Ch 2, Sec 2, [2.2.1]
- $\varphi_1 = 0,50$ for the decks above

n : Navigation coefficient as as defined Ch 4, Sec 2

p_0 : Sea pressure on bottom in the considered area, in kN/m^2, calculated according to [2.2.1] with z = 0

z_D : Vertical distance, in m, between the deck at side at the considered transverse section and the full load waterline (for monohull) or the baseline (for catamaran).

3.1.2 The pressure given in [3.1.1] is to be not less than the following minimal sea pressure p_{dmin}, in kN/m^2:

- in areas 1 and 2, as defined in Fig 4 (from fore perpendicular to $L_{WL}/3$ aft of fore perpendicular):

  $p_{dmin} = 15\ n\ \varphi_1$
- in areas 3 and 4 (elsewhere):

  $p_{dmin} = 10\ n\ \varphi_1$

where:

φ_1, n : As defined in [3.1.1].

3.2 Accommodation decks

3.2.1 The pressure on accommodation decks is to be not less than:

- $p_s = 5\ kN/m^2$, in large spaces (lounges, cinema, restaurant, kitchens, etc)
- $p_s = 3\ kN/m^2$, in cabins
- $p_s = 10\ kN/m^2$, in technical spaces and machinery spaces.

3.3 Superstructure deck

3.3.1 The pressure on exposed and accommodation superstructure decks are to be not less than the values given in [3.1] and [3.2].

However, when an exposed superstructure deck is not directly exposed to green seas effect, the pressure on this deck is to be taken not less than:

- $p_s = 5\ kN/m^2$ for decks accessible to passengers or crew members.
- $p_s = 3\ kN/m^2$ for decks not accessible to passengers or crew members.

4 Pressure on superstructures

4.1 General

4.1.1 In any point, the design pressure is to be taken as the sea pressure given in [4.2], without being taken less than the minimum pressure given in [4.3].

4.2 Sea pressure

4.2.1 The design pressure to be considered for scantlings of fore walls, side walls and aft walls of superstructures and deckhouses, in kN/m^2, is to be not less than:

$$p_S = 7 \cdot a \cdot c \cdot n \cdot (b \cdot f - z_S)$$

where:

a : Coefficient as given in Tab 2

c : Coefficient equal to:

- for monohull - motor yacht:
  $c = 0,3 + 0,7\ b_i / B_i$
- for monohull - sailing yacht: $c = 1,0$
- for catamarans (sailing or motor): $c = 0,5$

where:

B_i : Breadth of hull at the considered longitudinal location

b_i : Breadth of superstructure or deckhouse at the considered longitudinal location

Table 2 : Coefficient a

Location		a
Front wall	First tier	$2,0 + L_{WL}/ 120$
	2nd tier and above	$1,0 + L_{WL}/ 120$
Aft wall		$0,5 + L_{WL} / 1000$
Side walls		$0,5 + L_{WL} / 150$

n : Navigation coefficient as defined Ch 4, Sec 2, [3]

b : Coefficient equal to:

- in areas 1 and 2 as defined in Fig 4 (from fore end to $L_{WL}/3$ aft of fore perpendicular): $b = 1,5$
- in areas 3 and 4 (elsewhere): $b = 1,0$

f : Coefficient equal to:

$f = -2\ L_W^2 / 8000 + 0,1\ L_W - 1$

L_W : Wave length, in m, as defined in [1.1.3]

z_S : Vertical distance, in m, between the full load waterline and the calculation point, located as follows:

- for plating: mid-height of the elementary plate panel
- for stiffeners: mid-span.

4.3 Minimum pressures

4.3.1 As a rule, the design pressures to be considered for scantling of plating and supporting members of superstructures are to be not less than the minimum pressures p_{smin} given in Tab 3.

4.3.2 When the front wall is sloped aft, the front wall pressures values (sea pressures and minimum pressure) can be multiplied by cos a, where a is the angulation between z axis and straight line tangent to superstructure as shown on Fig 6.

5 Pressure in tanks

5.1 General

5.1.1 Scantlings of watertight bulkeadings of tanks are to be determined with design pressures given in Tab 4.

Tank testing conditions are also to be checked with testing pressures given in Tab 4.

Figure 6 : angulation of superstructures

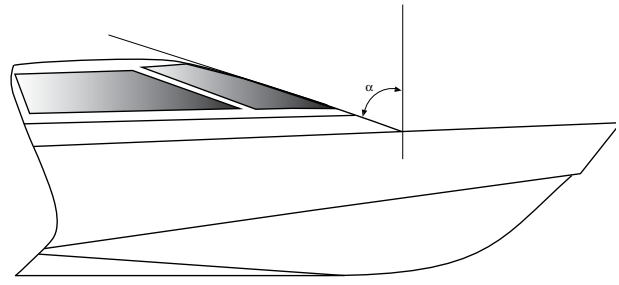


Table 3 : Minimum pressures

Type of wall	Location	p_{sumin} (in kN/m²)
Unprotected front wall	Lower tier, areas 1 and 2	21
	Lower tier, areas 3 and 4	15
	Upper tiers	10
Protected front wall or side walls	Lower tier	10
	Upper tiers	7
Unprotected aft wall	Lower tier, area 4	10
	Lower tier, areas 1, 2 and 3	7
	Upper tiers	7
Protected aft wall	Anywhere	5
Note 1: Areas are defined in Fig 4.		

Table 4 : Tank design and testing pressures

Type of tanks	Design pressure, in kN/m²	Testing pressure, in kN/m²
Water ballast Fresh water tank	$p_S = 11\ [(z_{AP} - z_{TOP}) + z_1]$	$p_T = 11\ (d_{AP} + z_1)$ without being less than p_V
Gas-oil or Fuel-oil tank	$p_S = 11\ [(z_{AP} - z_{TOP}) + z_1]$	$p_T = 11\ (d_{AP} + z_1)$ or $p = 10\ (2,4 + z_1)$ whichever is the greater, without being less than p_V

Note 1:

z_{TOP} : Z co-ordinate, in m, of the top of the tank

z_{AP} : Z co-ordinate, in m, of the moulded deck line of the deck to which the air pipes extend

d_{AP} : Vertical distance, in m, between the top of the tank and the top of the air pipe

z_1 : Vertical distance, in m, between the calculation point and the top of the tank

p_V : Safety pressure of valves, if applicable, in bar.

6 Pressure on bulkheads

6.1 General

6.1.1 Two types of watertight bulkheads are covered by the present Article :

- ordinary watertight bulkheads, fitted to partition the yacht into watertight compartments for damage stability purposes. The design pressure on such bulkheads is given in [6.1.3],
- watertight bulkheads forming boundary of a liquid capacity (Gas-oil, water ballast, fresh water, etc). The design pressure on such bulkheads is given in [5].

6.1.2 Non-watertight bulkheads are not subject to any design lateral pressure.

6.1.3 Scantlings of ordinary watertight bulkeads are to be determined with design pressures given in Tab 5.

However, in case of special arrangement of watertight bulkheads, the Society may request specific analysis and determination of design pressures to be used.

Table 5 : Watertight bulkheads design pressure

Type of bulkheads	Design pressure, in kN/m^2
Watertight bulkhead other than collision bulkhead	$p_S = 10\ (1.3T - z) > 0$
Collision bulkhead	$p_S = 10\ (D - z) > 0$
Note 1: T : Full draught, in m, z : Z co-ordinate, in m, of the calculation point D : Depth as defined in Ch 1, Sec 2, [3.6]	