SECTION 1 MOTIONS AND ACCELERATIONS

1 General

1.1 Application

1.1.1 The accelerations considered in this section are the dynamic vertical accelerations induced by ship motions and resulting in slamming phenomenon on bottom area.

1.1.2 The vertical acceleration (expressed in g) corresponds to the average of the 1 per cent highest accelerations in the most severe sea conditions expected, in addition to the gravity acceleration. This acceleration is referred to as design vertical acceleration.

1.1.3 Slamming phenomenon on bottom area generally occur on high speed motor yachts (heave acceleration) and on monohull sailing yachts (heave and pitch accelerations).

1.1.4 Specific slamming phenomenon occurring on fore part of underside of catamaran cross deck are directly dealt with in Ch 7, Sec 2 and are not depending of the vertical acceleration of the present Section.

1.1.5 The Society keeps the possibility to perform similar calculation for other types of yachts, if deemed necessary.

1.1.6 As an alternative to the formulas of this section, the Society may accept values of ship motions and accelerations derived from direct calculations or obtained from model test, when justified on the basis of yacht's characteristics and intended service. In general, the values of ship motions and accelerations to be determined are those which can be reached with a probability level of 10^{-5}. In any case, the model tests or the calculations, including the assumed sea scatter diagrams and spectra, are to be submitted to the Society for approval.

2 Design vertical acceleration

2.1 High speed motor yachts

2.1.1 The requirements of this Article apply to motor yachts:

- for which $V \geq 7{,}16\ \Delta^{1/6}$

  where V is the maximum speed in knots and Δ the moulded displacement at full load draught in sea water, in tonnes, and when hull lines have been so designed, and
- featuring planning hull to reach the contractual speed.

It is the designer responsibility to specify whether the hull is of planning type, and to specify the type of design as defined in [2.1.7] and [2.1.8].

Motor yachts for which $V \geq 10\ L_{WL}^{0,5}$ shall be individually considered by the Society.

2.1.2 The design vertical acceleration at LCG (ship's longitudinal centre of gravity), a_{CG} (expressed in g) is to be defined by the designer and indicated on drawings where the main characteristics of yacht are specified.

2.1.3 It is the designer's responsibility to provide for a relation between the speed and the significant wave height that provides a maximum vertical acceleration less than the design value. This relation may be determined on the basis of results of model test or full-scale measurements.

The table of the speed relative to the sea states, characterised by their significant wave height, is to be annexed to the Certificate of Classification according to Ship Rules, Part A, Ch 1, Sec 2, [4.10].

2.1.4 Where model test results or full-scale measurements are not available, the formula in [2.1.5] may be used to define maximum speeds compatible with design acceleration, depending on sea states having a significant height H_S.

2.1.5 The maximum allowable speed V in significant wave height H_S is related to the yacht's geometry and motion characteristics and to the design vertical acceleration a_{CG} by the following formula:

$$H_S = \left(\frac{3555 \cdot C_B \cdot a_{CG}}{\left(\frac{V}{\sqrt{L_{WL}}}\right)^2 \cdot (50 - \alpha_{dCG}) \cdot \left(\frac{\tau}{16} + 0,75\right)} - \left(0,084 \cdot \frac{B_W}{T}\right) \right) \cdot T$$

where:

H_S : Significant wave height, in m, corresponding to speed V

α_{dCG} : Deadrise angle, in degrees, at LCG, to be taken between 10° and 30°

τ : Trim angle during navigation, in degrees, to be taken not less than 4°

V : Ship speed in knots

C_B : Bloc coefficient

T : Full load draught, in m

B_W : Maximum breadth at full load waterline. For catamarans, B_W is to be taken as the sum of the breath of each hulls.

2.1.6 The formula in [2.1.5] is valid only if all following relationships are simultaneously complied with:

- $3500 < \Delta / (0{,}01\ L_{WL})^3 < 8700$
- $3 < L_{WL} / B_W < 5$
- $10° < \alpha_{dCG} < 30°$
- $0{,}2 < H_S / B_W < 0{,}7$
- $3{,}6 < V / (L_{WL})^{0.5} < 10{,}9$

Table 1 : foc for motor yacht

Type of design **(1)**	Cruise motor yacht	Sport motor yacht	Offshore raceing motor yacht	Motor yacht with specific equipments (e.g. safety belts)
foc	0,666	1,000	1,333	1,666

(1) See [2.1.8].

Table 2 : Soc for motor yacht

Sea conditions	Open sea **(1)**	Restricted open sea **(2)**	Moderate environment **(3)**	Smooth sea **(4)**
Soc	C_F **(5)**	0,3	0,23	0,14

(1) Category A in case of EC Directive, **unrestricted navigation** for Classification.

(2) Category B in case of EC Directive.

(3) Category C in case of EC Directive, **coastal area** for Classification.

(4) Category D in case of EC Directive, **sheltered area** for Classification.

(5) $C_F = 0,2 + \frac{0,6}{V/\sqrt{L_W}} \geq 0,32$

2.1.7 When the design vertical acceleration a_{CG} is not provided by the designer, the following value may be used, taking into account the type of design associated to the sea conditions. In such case the design vertical acceleration is to be mentioned on drawings.

$$a_{CG} = foc \cdot Soc \cdot \frac{V}{\sqrt{L_{WL}}}$$

where foc and Soc values are indicated in Tab 1 and Tab 2.

The sea areas referred to in Tab 2 are defined with reference to significant wave heights H_s which are exceeded for an average of not more than 10 percent of the year:

- Open-sea service: $H_s \geq 4,0$ m
- Restricted open-sea service: $2,5 \text{ m} \leq H_s < 4,0$ m
- Moderate environment service: $0,5 \text{ m} < H_s < 2,5$ m
- Smooth sea service: $H_s \leq 0,5$ m.

2.1.8 The type of design is to be defined by the yacht designer in order to estimate the foc parameter specified in Tab 1 and if necessary the maximum value of a_{CG}.

The type of design can be ranged as follows:

- Cruise Motor yacht:

  At maximum speed in service, the hull is mainly intended to be sustained by a combination of buoyancy and planning effect

- Sport Motor yacht:

  At maximum speed in service, the hull may be submitted during short moments to only planning effect

- Offshore racing Motor yacht:

  At maximum speed in service, the hull is consistently submitted to planning effect

- Motor yacht with specific equipments:

  The yacht is submitted to the same effect as Offshore racing Motor yacht and is fitted with safety arrangement (for example safety belts).

2.1.9 The design vertical acceleration a_{CG} may be taken not more than the values in Tab 3.

2.2 Sailing yacht - Monohull

2.2.1 The vertical accelerations considered in this article are induced by the ship behaviour at sea, and particularly heave and pitch.

The combination of heave and pitch acceleration is defined in [2.2.4]

2.2.2 The heave design vertical acceleration, in g, may be calculated as follows:

$a_H = 2,7 \text{ foc} \cdot \text{Soc}$

where foc and Soc are defined in Tab 4 and Tab 5.

The sea areas referred to in Tab 5 are defined with reference to significant wave heights H_s which are exceeded for an average of not more than 10 percent of the year:

- Open-sea service: $H_s \geq 4,0$ m
- Restricted open-sea service: $2,5 \text{ m} \leq H_s < 4,0$ m
- Moderate environment service: $0,5 \text{ m} < H_s < 2,5$ m
- Smooth sea service: $H_s \leq 0,5$ m.

Table 3 : Maximum values of a_{CG}

Type of yachts	Limit value of a_{CG}, in g
Cruise motor yacht	1,0
Sport motor yacht	1,5
Offshore racing motor yacht	2,0
Motor yacht with specific equipments (e.g. safety belts)	2,5

Table 4 : foc for sailing yacht

Type of design	Cruise sailing yacht	Sport sailing yacht	Race sailing yacht **(1)**
foc	0,666	1,000	1,333

(1) This value is given for information only, racing yachts not being covered by these Rules (see Pt A, Ch 1, Sec 1, [1.1.3]).

Table 5 : Soc for sailing yacht

Sea conditions	Open sea **(1)**	Restricted open sea **(2)**	Moderate environment **(3)**	Smooth sea **(4)**
Soc	0,30	0,27	0,23	0,20

(1) Category A in case of EC Directive, unrestricted navigation for Classification.
(2) Category B in case of EC Directive.
(3) Category C in case of EC Directive, **coastal area** for Classification.
(4) Category D in case of EC Directive, **sheltered area** for Classification.

2.2.3 The pitch design vertical acceleration a_P, in g, in any longitudinal location x, may be determined as follows, as shown on Fig 1.

$$a_P = a_{PFP} \cdot \frac{x - x_K}{L_{WL} - x_K}$$

without being taken less than 0

where:

x_K : Co-ordinate x of the centre of gravity of the keel measured from aft perpendicular

x : Co-ordinate x of the calculation point measured from aft perpendicular

a_{PFP} : Pitch vertical acceleration at fore perpendicular, equal to:

- $3\ a_H$ for race sailing yacht (see Note 1)
- $2{,}1\ a_H$ for bulb keel sailing yacht
- $1{,}5\ a_H$ for sailing yacht with bar keel
- a_H for lifting keel yachts

where a_H is calculated according to [2.2.2].

Note 1: This value is given for information only, racing yachts being not covered by these Rules (see Pt A, Ch 1, Sec 1, [1]).

2.2.4 Total design acceleration for slamming pressure

The total design vertical acceleration a_v to be considered for the calculation of the slamming pressure is to be taken equal to:

$a_V = a_H + a_p$

where:

a_H : Heave acceleration as defined in [2.2.2]

a_p : Pitch acceleration as defined in [2.2.3].

2.3 Slow speed motor yacht and Sailing yacht - multihulls

2.3.1 For slow speed motor yachts and for multihulls sailing yachts, no specific acceleration are to be calculated.

The effect of yacht motions are directly taken into consideration in the Rules formulae for the hydrodynamic loads (refer to Ch 7, Sec 1.

Figure 1 : Pitch acceleration longitudinal distribution