Table 10 — Size of safety signs and supplementary text

Parameter	Expected viewing distance, *D* (m)				
	$D \leq 0{,}6$	$0{,}6 < D \leq 1{,}2$	$1{,}2 < D \leq 1{,}8$	$1{,}8 < D \leq 2{,}4$	$D > 2{,}4$
Minimum height of warning sign (mm)	20,0	20,0	30,0	40,0	50,0
Minimum height of capital letters (mm)	2,4	4,8	7,2	9,6	12,0
Minimum height of lower case letters (mm) [a]	1,7	3,4	5,1	6,9	8,6

[a] For example, height of letter “e”.

9 Application

9.1 Deciding the design category

The design category for a particular boat is that for which the boat complies with all the appropriate requirements, as required by Clause 6 or Clause 7.

9.2 Meaning of the design categories

NOTE Refer to Table 11.

9.2.1 A boat given design category A is considered to be designed to operate in winds of less than Beaufort force 10 and the associated significant wave heights.

NOTE Typically such conditions might be encountered on extended voyages, for example across oceans, but can also occur inshore when unsheltered from the wind and waves for several hundred nautical miles. Depending on atmospheric conditions, winds can gust to about 32 m/s.

9.2.2 A boat given design category B is considered to be designed to operate in winds of Beaufort force 8 or less and the associated significant waves heights of up to 4 m.

NOTE Typically such conditions might be encountered on offshore voyages of sufficient length but can also occur on coasts where shelter might not always be immediately available. These conditions can also be experienced on inland seas of sufficient size for the wave height to be generated. Depending on atmospheric conditions, winds can gust to about 27 m/s.

9.2.3 A boat given design category C is considered to be designed to operate in typical steady winds of Beaufort force 6 or less and the associated significant waves heights of up to 2 m.

NOTE Typically such conditions might be encountered on exposed inland waters, in estuaries, and in coastal waters in moderate weather conditions. Depending on atmospheric conditions, winds can gust to about 18 m/s.

9.2.4 A boat given design category D is considered to be designed to operate in typical steady winds of Beaufort force 4 or less and the associated significant waves heights of up to 0,3 m and occasional waves of 0,5 m height.

NOTE Typically such conditions might be encountered on sheltered inland waters, and in coastal waters in fine weather. Depending on atmospheric conditions, winds can gust to about 12 m/s.

9.2.5 The significant wave height is the mean height of the highest one-third of the waves, which approximately corresponds to the wave height estimated by an experienced observer. Some waves will be double this height.

Table 11 — Summary of design category descriptions

Parameter	Design category			
	A	B	C	D
Typical Beaufort wind force	<10	≤8	≤6	≤4
Wave height up to	approx. 7 m significant	4 m significant	2 m significant	0,3 m significant 0,5 m maximum
Maximum average wind speed for 10 min	24,4 m/s	20,7 m/s	13,8 m/s	7,9 m/s

NOTE 1: The significant wave height is the mean height of the highest one-third of the waves, which approximately corresponds to the wave height estimated by an experienced observer. Some waves will be double this height.

NOTE 2: According to atmospheric conditions, gusts may temporarily increase the wind speed.

NOTE 3: Maximum average wind speed taken from UK Met Office Fact sheet 6.

Annex A
(normative)

Full method for required downflooding height

The required downflooding height may be calculated according to the method set out below instead of using Figure 2. In all cases, the limits given in Table A.1 apply to the required height calculated by the formula below.

Table A.1 — Limits on required downflooding height

Dimensions in metres

Design category	A	B	C	D
$h_{D(R)}$ (m) shall be not less than	0,5	0,4	0,3	0,2
$h_{D(R)}$ (m) shall be not more than	1,41	1,41	0,75	0,4

The downflooding height required ($h_{D(R)}$) is calculated separately for each downflooding opening as follows:

$$h_{D(R)} = H_1 \times F_1 \times F_2 \times F_3 \times F_4 \times F_5 \qquad \text{(A.1)}$$

where

H_1 $= L_H/15$;

F_1 is the opening position factor (varies between 0,5 and 1,0),

= 1,0 where the downflooding opening is in the periphery of the boat, e.g. for undecked, open boats, or openings in topsides:

$$F_1 = (1 - x_D/L_H) \text{ or } (1 - y_D/B_H), \qquad \text{(A.2)}$$

whichever is greater, see Figure A.1.

where

x_D is the longitudinal distance of a downflooding opening from the nearest extremity of L_H;

y_D is the least transverse distance of a downflooding opening from the periphery of the boat.

F_2 is the opening size factor (varies between 0,6 and 1,0):

$$F_2 = 1{,}0, \text{ if } a \geq (30L_H)^2 \qquad \text{(A.3)}$$

where

a is the total combined area of openings up to the top of any downflooding opening, expressed in square millimetres (mm^2);

$$F_2 = 1 + \frac{x'_D}{L_H}\left(\frac{\sqrt{a}}{75L_H} - 0,4\right) \text{ if } a < (30L_H)^2; \qquad \text{(A.4)}$$

where

x'_D is the longitudinal distance of the opening from the forward limit of L_H.

F_3 is the recess size factor, greater than 0,7 but never to be taken as greater than 1,2:

= 1,0 where the opening is not a recess, otherwise:

= 0,7 if the recess is quick-draining;

= 0,7 + $k^{0,5}$ if the recess is not quick-draining;

where

$$k = V_R/(L_H B_H F_M) \qquad \text{(A.5)}$$

where

V_R is the volume of a non-quick-draining recess, expressed in cubic metres.

F_4 is the displacement factor (typically this is between about 0,7 and 1,1):

$$= \left(\frac{10\ V_D}{L_H\ B^2}\right)^{1/3} \qquad \text{(A.6)}$$

where

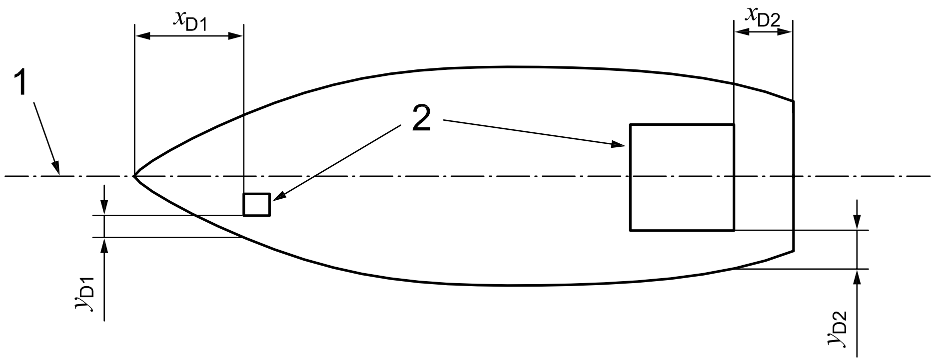
V_D is the volume of displacement in the maximum load condition, $V_D = m_{LDC}/1\ 025$;

B is B_H for monohull, and B_{WL} for catamarans and trimarans.

F_5 is the flotation factor:

= 0,8 for boats using options 3 and 4 (see Table 2);

= 1,0 for all other boats.



Key

1 centreline

2 downflooding openings

Figure A.1 — Dimensions x_D and y_D

Annex B
(normative)

Methods for calculating downflooding angle

B.1 Choice of method

Either of the methods B.2 or B.3 can be used.

B.2 Theoretical calculation

The downflooding angle is most accurately determined by computer calculation, using the shape of the hull from the lines plan. Most software packages for calculating stability have provision for finding the angle of heel at which points with specified coordinates become submerged. Thus, if righting moments are determined using computer software, downflooding angles can be obtained at the same time.

B.3 Approximate method for downflooding angles up to 60°

The following approximate method can be used for estimating the downflooding angle of monohulls, but is only suitable for angles less than about 60°:

$$\phi_D = \tan^{-1}(z_D / y'_D) \tag{B.1}$$

$$\phi_D \text{ is the angle whose tangent is } (z_D / y'_D) \tag{B.2}$$

where

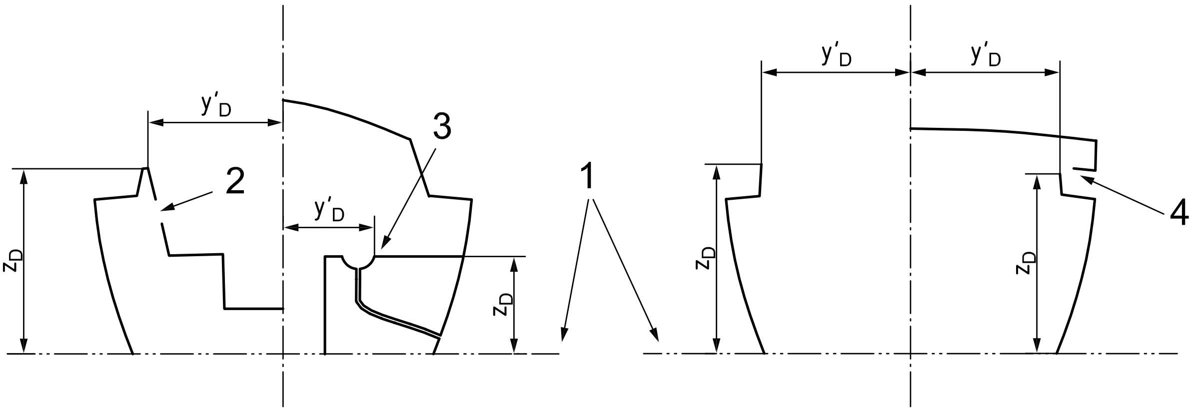
z_D is the height of the downflooding point above the waterline, expressed in metres;

y'_D is the transverse distance, expressed in metres, of the downflooding point from the centre-line of the boat.

See Table B.1 and Figure B.1.

Table B.1 — Approximate method for downflooding angle

z_D / y'_D	ϕ_D degrees
0,10	5,7
0,15	8,5
0,20	11,3
0,25	14,0
0,30	16,7
0,35	19,3
0,40	21,8
0,45	24,2
0,50	26,6
0,55	28,8
0,60	31,0
0,65	33,0
0,70	35,0
0,75	36,9
0,80	38,7
0,85	40,4
0,90	42,0
0,95	43,5
1,00	45,0
1,05	46,4
1,10	47,7
1,15	49,0
1,20	50,2
1,30	52,4
1,40	54,5
1,50	56,3
1,60	58,0
1,70	59,5



Key

1 waterline

2 downflooding opening protected by coaming

3 example of internal downflooding opening

4 example of engine air inlet

Figure B.1 — Approximate method for downflooding angle

Annex C
(normative)

Determining the curve of righting moments

C.1 Method

The curve of righting moments shall be determined using the method described in C.3. The mass and centre of gravity used shall conform to C.2.

C.2 Mass and centre of gravity

Where preliminary estimates are used at the design stage, these shall be subsequently superseded by the use of data for the boat as finally built.

C.2.1 Mass

The mass used can be found using any of the following methods:

a) direct weighing using crane weigher, weighbridge, load cells or similar, corrected to the appropriate displacement mass;

b) calculation from the lines plan using a waterline observed on a boat afloat in a known load condition, by means of freeboards or draughts, and using a measured specific gravity for the water, and corrected to the appropriate loading condition;

c) calculation based on the mass of a closely similar boat derived by either a) or b) above, with the mass of known changes determined solely by calculation.

Method c) shall only be used where the change in mass in the empty craft condition is less than 10 %.

C.2.2 Vertical centre of gravity

The vertical position of the centre of gravity (VCG) can be found using any of the following methods:

a) an inclining experiment in water (see 3.6.7), the results being corrected to the appropriate loading condition;

b) an inclining experiment in air using a known length of suspension and moving weights transversely (as in water), the results being corrected to the appropriate loading condition;

c) calculation based on the calculated mass and centres of gravity of all individual components, raised by an addition of 5 % of (F_M + T_C).

In deriving the VCG, any centreboard or keel shall be in the raised position unless it can be fixed in the lowered position and an appropriate instruction is given in the owner's manual.

Method a) shall not be used for boats with a metacentric height greater than 5,0 m (such as multihulls), since inclining experiments in water for such boats are liable to significant inaccuracies.

Method c) shall not be used for boats with a metacentric height of less than 1,5 m, since significant inaccuracies may result. It may, however, be used for preliminary assessment.

For the purposes of determining the curve of righting levers:

a) for calculations for the minimum operating condition: the mass of the crew shall be at the main control position;

b) for calculations for the loaded arrival condition:

   1) fuel and water shall be located in the fixed tanks,

   2) provisions shall be stowed in an appropriate location,

   3) the mass of additional crew (crew limit less that required for m_{MO}) shall be added at sheerline height at the mid-length of L_{H}.

C.2.3 Longitudinal centre of gravity

The longitudinal position of the centre of gravity (LCG) of the empty boat can be found using any of the following methods:

a) method b) or c) in C.2.1;

b) calculation based on the calculated mass and centres of gravity of all individual components;

c) suspension of the boat in air, identifying the LCG using a plumb line from the suspension point.

C.2.4 Free-surface effect

Boats having any tank (fuel, fresh, black and grey water, live wells, oils, etc.) that has a maximum transverse dimension greater than 0,35B_{H} shall have their righting moments calculated with the contents of all tanks as given in Table C.1.

If tanks are linked by cross-connections that are kept open when the boat is in use, then the maximum transverse dimension of such a tank shall be measured between the extremes of the linked tanks.

Table C.1 — Contents of tanks for calculation of righting moments

Tank	Loading condition	
	Loaded arrival	Minimum operating
Fuel	10 %	0 %
Fresh water	10 %	0 %
Black/grey water	95 %	0 %
Oils	10 %	0 %
Bait tanks, live wells	95 %	0 %

Where applicable, free-surface effect shall be represented either by a virtual increase in the boat's VCG (see below) or by using computer software that models the movement of fluid in tanks with trim and heel.

$$\text{virtual increase in the boat's VCG due to each tank} = \frac{\text{SMA}_{\text{TANK}} \times \rho_{\text{TANK}}}{m}, \text{ expressed in metres} \quad \text{(C.1)}$$

where

ρ_{TANK} is the density of fluid in tank, expressed in kg/m^3

m is the mass of the boat in the relevant loading condition, expressed in kilograms

SMA_{TANK} is the second moment of area of waterplane of tank contents about longitudinal axis through its centre of area, expressed in m^4

If tanks are linked by cross-connections that are kept open when the boat is in use, then the value of SMA_{TANK} shall be calculated assuming that all linked tanks act as one.

C.3 Determination by rigorous calculation

C.3.1 The curve of righting levers for a boat in calm water is most accurately determined by computer calculation, using specialist software which correctly takes account of the changes in trim and heave that take place as a boat heels. It is desirable wherever possible to use a vertical position of the centre of gravity (VCG) which has been derived from an inclining experiment, except in the case of boats with exceptionally high initial stability (such as multihulls) when a careful calculation of VCG will prove more accurate. The longitudinal position of the centre of gravity (LCG) shall be derived by calculation from the longitudinal centre of buoyancy obtained from the inclining experiment.

C.3.2 In defining the watertight hull, cockpits, recesses, bow thruster tunnels and all appendages affecting the buoyancy shall be correctly represented. Righting lever curves shall normally be calculated with recesses modelled, assuming that, at each heel angle, such recesses flood up to the exterior water level. However, up to the angle of heel at which recesses would otherwise fill (e.g. coaming submergence), righting levers may alternatively be calculated ignoring flooding of recesses through

- freeing ports equipped with non-return flaps which are watertight from the exterior to degree 3 of ISO 12216, or
- drains having a combined cross-sectional area smaller than three times the minimum area required to comply with ISO 11812 for quick-draining cockpits.

C.3.3 The buoyancy of superstructures and deckhouses may be included in the calculation, provided that the structure (including windows) is both watertight in accordance with ISO 12216 and has sufficient structural strength to survive the boat being rolled to a heel angle through 180°.

C.3.4 The buoyancy of masts and standing rigging (but not booms, gaffs or running rigging) may be included in the calculation of righting lever if desired. In this case, only the buoyant volume shall be included, i.e. the internal volume of free-flooding or non-watertight masts shall not be included. The effect of the mass of masts is included in the inclining experiment results.

C.3.5 Righting moment is equal to the righting lever in metres multiplied by the boat mass in kilograms multiplied by 9,806, and is expressed in newton metres.