Nederlandse

norm

Ontwerp

NEN-EN-ISO 12217-1

Pleziervaartuigen - Beoordeling en classificatie van stabiliteit en drijfvermogen - Deel 2: Boten zonder zeil met een romplengte groter dan of gelijk aan 6 m (ISO/DIS 12217-1:1999,IDT)

Publicatie uitsluitend voor commentaar

Small craft - Stability and buoyancy assessment and categorization - Part 1: Non-sailing boats of hull length greater than or equal to 6 m (ISO/DIS 12217-1:1999,IDT)

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Commentaar voor 2000-01-15

Als Europees normontwerp is gepubliceerd:prEN ISO 12217-1:1999,IDT

Definitief vastgestelde normen zullen als Nederlandse norm gelden. Daarom wordt dit normontwerp in Nederland voor commentaar gepubliceerd. Op het ontwerp ingebracht commentaar zal aan de bevoegde normcommissie worden voorgelegd die hiermee rekening zal houden bij de bepaling van de Nederlandse stem. Indien er geen bezwaar bij het NNI wordt ingebracht, kan dat leiden tot ongewijzigd definitieve vaststelling van het ontwerp als norm.

Van Europese normen bestaan drie officiële versies: Engels, Frans en Duits. Voor Nederland zal de Engelse versie gelden, tenzij voor een geautoriseerde versie in het Nederlands wordt gekozen.

Normcommissie 330 044 "Pleziervaartuigen"

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DRAFT INTERNATIONAL STANDARD ISO/DIS 12217-1

ISO/TC **188** Secretariat: **SIS**

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Small craft — Stability and buoyancy assessment and categorization —

Part 1: Non-sailing boats of hull length greater than or equal to 6 m

Petits navires — Catégorisation et évaluation de la stabilité et de la flottabilité —

Partie 1: Navires sans voiles d'une longueur de coque supérieure ou égale à 6 m

ICS 47.080

ISO/CEN PARALLEL ENQUIRY

The CEN Secretary-General has advised the ISO Secretary-General that this ISO/DIS covers a subject of interest to European standardization. **In accordance with subclause 5.1 of the Vienna Agreement, consultation on this ISO/DIS has the same effect for CEN members as would a CEN enquiry on a draft European Standard.** Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month FDIS vote in ISO and formal vote in CEN.

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12217 was prepared by Technical Committee ISO/TC 188, Small craft.

Annexes A, B, C, D, E and F form an integral part of this part of ISO 12217. Annexes G, H and J are for information only.

ISO 12217 consists of the following parts, under the general title *Small craft — Stability and buoyancy assessment and categorization*:

— *Part 1: Non-sailing boats of 6 m length of hull and over*

— *Part 2: Sailing boats of 6 m length of hull and over*

— *Part 3: Boats less than 6 m length of hull*

Introduction

This International Standard enables the limiting environmental conditions to be determined for which an individual boat has been designed.

CAUTION !

Compliance with this International Standard does not guarantee total safety or total freedom of risk from capsize or sinking.

1 Scope

This part of ISO 12217 specifies methods for evaluating the stability and buoyancy of intact (i.e. undamaged) boats. The flotation characteristics of craft vulnerable to swamping are also encompassed.

The evaluation of stability and buoyancy properties using this part of ISO 12217 will enable the boat to be assigned to a design category (A, B, C or D) appropriate to its design and maximum total load.

This part of ISO 12217 is principally applicable to boats propelled by human or mechanical power of 6 m and up to and including 24 m length of hull. However, it may also be applied to boats of under 6 m if they do not attain the desired design category using Part 3 of ISO 12217 and they are decked and have quick-draining recesses which comply with ISO 11812.

This part of ISO 12217 excludes

— inflatable and rigid-inflatable boats up to 8 m covered by ISO 6185;

— canoes, kayaks, or other boats with a beam of less than 1,1 m;

— hydrofoils and hovercraft when operating in the dynamically supported mode;

— submersibles.

It does not include or evaluate the effects on stability of towing, fishing, dredging, or lifting operations, which should be separately considered if appropriate.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12217. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12217 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2896:1987, *Cellular plastics, rigid — Determination of water absorption.*

ISO 8666:—[1], *Small craft — Principal data.*

ISO 11812:—[1], *Small craft — Watertight cockpits and quick-draining cockpits.*

[1] To be published.

ISO 12216:—[1], *Small craft — Windows, hatches, portlights, deadlights and doors.*

ISO 14946:—[1], *Small craft — Maximum load capacity.*

3 Terms and definitions

For the purposes of this part of ISO 12217, the following terms and definitions apply.

3.1 Primary

3.1.1
design category
description of the sea and wind conditions for which a boat is assessed by this part of ISO 12217 to be suitable

NOTE See also 7.2.

3.1.2
non-sailing boat
boat for which the primary means of propulsion is other than by wind power, having:

$$A_S < 0{,}07 \times (m_{LDC})^{2/3}$$

where

A_S is the area of sails in profile according to ISO 8666;

m_{LDC} is the loaded displacement mass of the boat, expressed in kilograms.

3.1.3
recess
any volume open to the sky that may retain water

EXAMPLE Cockpits, wells, open volumes or areas bounded by bulwarks or coamings.

NOTE Cabins, shelters or lockers provided with closures to the watertightness requirements of ISO 12216 are not recesses.

3.1.4
quick-draining recess
recess fulfilling all the requirements of ISO 11812 for 'quick-draining cockpits and recesses'.

NOTE According to its characteristics, a cockpit may be considered to be quick-draining for <u>one</u> design category, but maybe not for a higher one.

3.1.5
watertight recess
recess fulfilling all the requirements of ISO 11812 for 'watertight cockpits and recesses'.

NOTE This term only implies requirements in respect of watertightness and sill heights, but not those for drainage.

3.1.6
fully decked boat
boat in which the horizontal projection of the sheerline area comprises any combination of

— decking with appliances watertight in accordance with ISO 12216, and/or

— quick-draining recesses complying with ISO 11812, and/or

— watertight recesses complying with ISO 11812 with a volume of less than $L_H B_H F_M /40$

3.1.7
partially decked boat
boat in which at least two-thirds of the horizontal projection of the sheerline area is equipped with decking, cabins, shelters or rigid covers which are watertight according to ISO 12216 and designed to shed water overboard, in which area all that within L_H / 3 from the bow and also the area 100 mm inboard from the periphery of the boat (excluding the transom) are included

3.2 Downflooding

3.2.1
downflooding opening(s)
any opening (including the edge of a recess) that may admit water into the interior or bilge of a boat, or a recess

3.2.2
downflooding angle
ϕ_D
angle of heel at which downflooding openings specified in 6.1.3 become immersed, the boat being in calm water (upright) at loaded displacement mass and design trim

NOTE Where openings are not symmetrical about the centreline of the boat, the case resulting in the least angle is used.

3.2.3
downflooding height
h_D
least height above the waterline to downflooding openings specified in 6.1.2.1 c), with the boat upright in calm water at loaded displacement mass and design trim

3.3 Dimensions, areas, and angles

3.3.1
length of hull
L_H
overall length of the hull according to ISO 8666

3.3.2
length waterline
L_{WL}
length of the hull of a boat measured in the plane of the waterline at which the boat floats when upright, at loaded displacement mass and design trim

NOTE For multihull boats, this length relates to that of the longest individual hull.

3.3.3
beam of hull
B_H
maximum beam of the hull according to ISO 8666

NOTE For catamaran and trimaran boats, B_H is to be measured as the maximum beam across the outer hulls.

3.3.4
beam waterline
B_{WL}
greatest beam measured to ISO 8666 at the waterline which, for multihull boats, is the sum of the maximum waterline beams of all hulls, the boat being upright, at loaded displacement mass and design trim

3.3.5
freeboard amidships
F_M
distance of the sheerline or deck above the waterline according to ISO 8666, the boat being upright, at loaded displacement mass and design trim at L_H /2

3.3.6
draught of the canoe body
T_C
draught of the main buoyant part of the hull(s) below the waterline, as defined in ISO 8666, the boat being upright at loaded displacement mass and design trim

3.3.7
windage area
A_{LV}
projected profile area of hull, superstructures, deckhouses and spars above the waterline at the loaded displacement mass, at zero heel angle

NOTE Canopies and screens that are likely to be erected when underway in bad weather are included, e.g. cockpit dodgers, pram hoods.

3.3.8
angle of vanishing stability
ϕ_V
angle of heel nearest the upright (other than upright) at loaded displeacement mass at which the transverse stability righting moment is zero; determined assuming that there is no offset load, and that all potential downflooding openings are assumed to be watertight

NOTE Where a boat has recesses which are not quick-draining, ϕ_V is to be taken as the downflooding angle to these recesses, unless such recesses are fully accounted for in determining ϕ_V.

3.4 Condition, mass, and volume

3.4.1
light craft condition
boat equipped as the light craft mass according to ISO 8666 with the following added as appropriate:

a) where provision is made for propulsion by outboard engine(s) of more than 3 kW, the heaviest engine(s) recommended for the boat by the manufacturer, mounted in the working position(s);

b) Where batteries are fitted, they are to be mounted in the position intended by the builder. The mass allowed for outboard engine batteries is not to be less than that given in column 3 of Tables E.2 and E.3. If there is no specific stowage provided for batteries, the mass of one battery for each engine over 11,3 kW is to be allowed for, and located within 1,0 m of the engine location.

c) mast(s), boom(s), and other spar(s) on board and rigged in the stowed position ready for use, but not set; all standing and running rigging in place;

d) any sails supplied by the builder, onboard and rigged ready for use, but not hoisted, e.g. mainsail on boom, roller furling sails furled, hanked foresails on stay stowed on foredeck.

3.4.2
maximum total load
m_{MTL}
load which the boat is designed to carry in addition to the light craft condition, comprising the manufacturer's maximum recommended load as defined in ISO 14946 and marked on the builders plate, plus liquids (e.g. fuel, oils, fresh water, water in bait tanks and live wells) to the maximum capacity of fixed tanks

3.4.3
loaded displacement mass
m_{LDC}
mass of the boat in the light craft condition with the maximum total load added

3.4.4
loaded displacement volume
∇
volume of displacement of the boat that corresponds to the loaded displacement mass taking the density of water as 1 025 kg/m^3

3.5 Other definitions

3.5.1
calculation wind speed
v_W
mean or average steady wind speed to be used for calculations

3.5.2
crew
collective description of all persons onboard a boat

3.5.3
crew limit
CL
maximum number of crew (with a mass of 75 kg each) used when assessing the design category

3.5.4
design trim
longitudinal attitude of a boat when upright at loaded displacement mass, with crew, stores and equipment in the positions designated by the designer or builder

3.5.5
flotation elements
consist of one of the following:

— air tank:	Tank made of hull construction material, integral with hull or deck structure;
— air container:	Container made of stiff material, not integral with the hull or deck structure;
— low density material:	Material with a specific gravity of less than 1,0 primarily incorporated into the boat to enhance the buoyancy when swamped;
— rib collar:	Heavy duty tubular collar fitted around the periphery of the boat and always intended to be inflated whenever the boat is being used;
— inflated bag:	Bag made of flexible material, not integral with hull or deck, accessible for visual inspection and intended always to be inflated when the boat is being used.

NOTE Bags intended to be inflated automatically when immersed (e.g. at the masthead as a means to prevent inversion) are not to be regarded as flotation elements.

3.5.6
inclining experiment
method by which the vertical position of the centre of gravity (VCG) of a boat can be determined

NOTE 1 The VCG together with a knowledge of the shape of the hull (the lines plan) and the position of the waterline in a known loading condition, enable all the intact stability parameters to be calculated.

NOTE 2 For a full description of how to conduct an inclining experiment, standard naval architecture textbooks should be consulted (e.g. Principles of Naval Architecture, published by S.N.A.M.E) or refer to American Society for Testing and Materials Standard Guide for Conducting a Stability Test (ASTM F-1321-90).

3.5.7
loaded waterline
waterline of the boat when upright at loaded displacement mass and design trim

3.5.8
righting moment
at a specific heel angle in calm water, the restoring moment generated by the transverse offset of the centre of gravity of the boat from the centre of buoyancy of the submerged part of the hull

NOTE 1 The righting moment varies with heel angle and is usually plotted graphically against roll angle. Righting moments are most accurately derived by computer from a knowledge of the hull shape and the location of the centre of gravity. Other more approximate methods are also available. The righting moment varies substantially with hullform, centre of gravity position, boat mass and trim attitude.

NOTE 2 Righting moment is expressed in Newton-metres.

3.5.9
righting lever
GZ
righting moment divided by the product of mass, in kilograms, and acceleration due to gravity (9,806 m/s^2)

3.5.10
watertightness degree
degree of watertightness as specified in ISO 11812 and ISO 12216, and summarised as follows:

Degree 1: Degree of tightness providing protection against effects of continuous immersion in water

Degree 2: Degree of tightness providing protection against effects of temporary immersion in water

Degree 3: Degree of tightness providing protection against splashing water

Degree 4: Degree of tightness providing protection against water drops falling at an angle of up to 15° from the vertical

4 Symbols

The following symbols and associated units are used in this part of ISO 12217.

Table 1 — Symbols

Symbol	Unit	Meaning
ϕ	degree (°)	Angle of heel
ϕ_D	degree (°)	Actual downflooding angle
$\phi_{D(R)}$	degree (°)	Required downflooding angle, see 6.1.3
ϕ_{GZmax}	degree (°)	Angle of heel at which maximum righting moment occurs
ϕ_O	degree (°)	Heel angle during offset load test, see 6.2
$\phi_{O(R)}$	degree (°)	Maximum permitted heel angle during offset load test, see 6.2
ϕ_R	degree (°)	Assumed roll angle in a seaway
ϕ_V	degree (°)	Angle of vanishing stability, see 3.3.8
ϕ_W	degree (°)	Heel angle due to calculation wind speed
A_C	m^2	Area of deck or cockpit available to the crew, see 6.3
A_{LV}	m^2	Windage area of hull in profile at loaded displacement mass and design trim
A_S	m^2	Area of sails in profile according to ISO 8666
B_H	m	Beam of hull according to ISO 8666

Symbol	Unit	Meaning
B_{WL}	m	Beam waterline in loaded displacement condition according to ISO 8666. In the case of multihulls, this is the sum of the waterline beam of each of the hulls.
CD		Crew density = proportion of boat plan area needed for crew
CL		Crew limit = maximum number of persons on board
d		Density coefficient for submerged test weights
F_M	m	Freeboard midships according to 3.3.5 and ISO 8666
GM	m	Transverse metacentric height
GZ	m	Righting lever = righting moment (Nm) / (mass (kg) x 9,806)
h_D	m	Actual downflooding height, according to 6.1.2
$h_{D(R)}$	m	Required downflooding height, according to 6.1.2
LCG		Longitudinal position of the centre of gravity
L_H	m	Length of hull according to ISO 8666
L_{WL}	m	Length of waterline in loaded displacement condition according to ISO 8666
M_C	Nm	Maximum offset load moment due to crew, see B.3
m_{LDC}	kg	Mass of the boat in loaded displacement condition
m_{MTL}	kg	Mass of the maximum total load
M_W	Nm	Maximum heeling moment due to wind, see 6.3
OG	m	Height of centre of gravity above waterline
T_C	m	Draught of canoe body according to ISO 8666 and 3.3.6
∇	m^3	Loaded displacement volume according to 3.4.4
v_W	m/s	Calculation wind speed
VCG	m	Vertical position of the centre of gravity
x_D	m	Longitudinal distance of downflooding opening from nearest end of boat
x_D'	m	Longitudinal distance of downflooding opening from forward end of boat
y_D	m	Transverse distance of downflooding opening from periphery of boat
y_D'	m	Transverse distance of downflooding opening off centreline
z_D	m	Height above waterline of downflooding opening

5 Procedure

5.1 Maximum total load

Decide on the crew limit and the maximum total load that the boat is intended to carry in accordance with the definitions. The crew limit shall not exceed that determined in accordance with ISO 14946.

5.2 Sailing or non-sailing

Confirm that the boat is non-sailing. Non-sailing boats are those where $A_S < 0,07 \times (m_{LDC})^{2/3}$.

NOTE Other boats are sailing boats and should be assessed using Part 2 of ISO 12217.

5.3 Tests and calculations to be applied

Non-sailing boats shall comply with all the requirements of any one of six options according to amount of flotation and decking, and whether the boat is fitted with a quick-draining cockpit. These options and the tests to be applied (as described in Clause 6) are given in Table 2. The design category finally given is that for which the boat satisfies **all** the relevant requirements of any one of these options.

If the boat is fully decked and has watertight recesses complying with ISO 11812, it may be assessed according to options 1 and 2 but complying with all the requirements when such recesses are sealed against leakage and filled to overflowing with water.

NOTE Some monohull boats, especially those of round bilge hullform, experience a significant reduction in transverse stability when engine propelled above a critical speed. Annex J provides guidance on how to detect such behaviour.

Table 2 — Tests to be applied

Option	1	2	3	4	5	6
Categories possible	A and B	C and D	B	C and D	C and D	C and D
Decking or covering	Fully decked	Fully decked	Any amount	Any amount	Partially decked	Any amount
Downflooding openings	6.1.1	6.1.1	6.1.1	6.1.1	6.1.1	6.1.1
Downflooding height test	6.1.2	6.1.2	6.1.2	6.1.2[a]	6.1.2	6.1.2
Downflooding angle	6.1.3	6.1.3	6.1.3	6.1.3	6.1.3	
Offset load test	6.2	6.2	6.2	6.2	6.2	6.2
Resistance to waves+wind	6.3		6.3			
Heel due to wind action		6.4[b]		6.4[b]	6.4[b]	6.4[b]
Flotation test			6.5	6.5		
Flotation material			Annex F	Annex F		

a This test is not required for boats assessed using option 4 if, during the swamped load test in Annex E, the boat has been shown to support an equivalent dry mass of one third more than maximum total load.

b The application of 6.4 is only required for boats where $A_{LV} \geq L_H B_H$.

6 Tests, calculations and requirements

6.1 Downflooding

6.1.1 Downflooding openings

All closing appliances fitted to downflooding openings shall comply with ISO 12216, according to design category and appliance location area. Opening type appliances fitted in the hull below the minimum required downflooding height shall be tightness degree 1 or 2. No opening type appliances shall be fitted in the hull below 0,2 m above the waterline at loaded displacement mass unless

a) they are emergency escape hatches or appliances fitted with screwed closures, or

b) the compartment so affected is of such restricted volume that even if flooded the boat satisfies all the requirements, or

c) the boat is of design category C or D and when at loaded displacement mass would not sink if the affected compartment was flooded as a result of the appliance being left open.

For boats to be given design category A or B, downflooding openings not fitted with any form of closing appliance shall only be permitted if they are essential for ventilation or engine combustion requirements.

6.1.2 Downflooding height

6.1.2.1 Test

This test is to demonstrate sufficient margins of freeboard for the boat at loaded displacement mass before water is shipped aboard.

This test is not required for boats assessed using option 4 if, during the buoyancy test in E.3.2, the boat has been shown to support an equivalent dry mass of one third more than maximum total load, or if the boat does not take on water when heeled to 90° from the upright in the light craft condition.

This test shall be performed using people as described below, using test weights to represent people (at 75 kg per person), or by calculation (using a lines plan and displacement derived by a weighing or measured freeboards).

a) Select people up to the crew limit, having an average mass of not less than 75 kg.

b) In calm water load the boat with all items of maximum total load, with the people positioned in accordance with ISO 14946 so as to achieve the design trim.

c) Measure the height from the waterline to the points at which water could first begin to enter any downflooding opening except

   1) watertight recesses with a combined volume less than $(L_H B_H F_M)/40$, or quick-draining recesses;

   2) piped drains from quick-draining recesses or from watertight recesses which if filled would not lead to downflooding or capsize when the boat is upright;

   3) appliances which comply with ISO 11216;

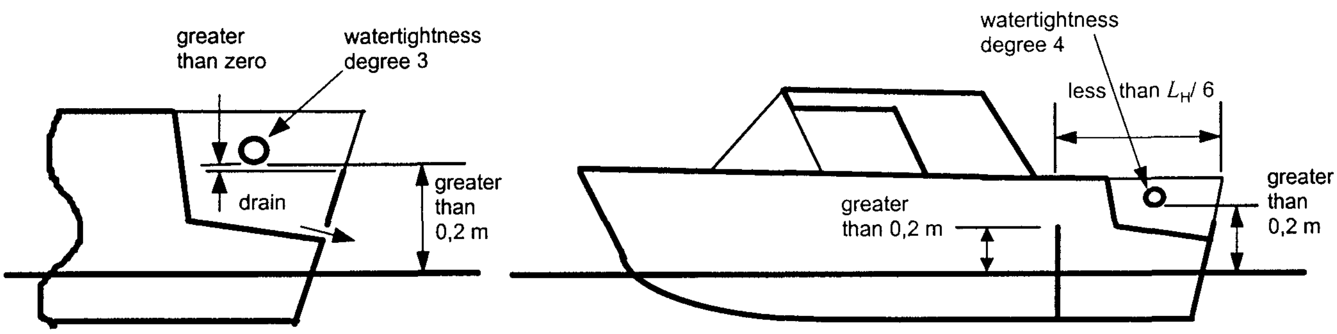
   4) engine exhausts or other openings that are only connected to watertight systems;

   5) openings in the sides of outboard engine wells which are either of:

      i) watertightness degree 2 and having the lowest point of downflooding more than 0,05 m above the loaded waterline for boats using option 1, or 0,1 m for all other boats;

      ii) watertightness degree 3 and having the lowest point of downflooding more than 0,2 m above the loaded waterline and also above the top of the transom in way of the engine mounting, provided that at least two well drain holes are fitted (each having a minimum area of 500 mm^2);

      iii) watertightness degree 4 and having the lowest point of downflooding more than 0,2 m above the loaded waterline, provided that the part of the interior or non-quick-draining spaces into which water may be admitted has a length less than $L_H/6$ and from which water up to 0,2 m above the loaded waterline cannot drain into other parts of the interior or non-quick-draining spaces of the boat.



Downflooding openings within the boat such as outboard engine trunks or free-flooding fish bait tanks shall be considered.

Figure 1 — Openings in outboard engine wells

d) Where a downflooding opening is protected by a higher coaming around the recess from which it leads, the downflooding height shall be measured to the lowest point of that coaming.

6.1.2.2 Requirements

a) Determine the design category by comparing the measurements with the requirements for minimum downflooding height, as modified by (b) to (d) below, using either

1) the method of Annex A, which generally gives the lowest requirement; or

2) Figures 2 and 3 which are simpler to apply being based only on boat length.

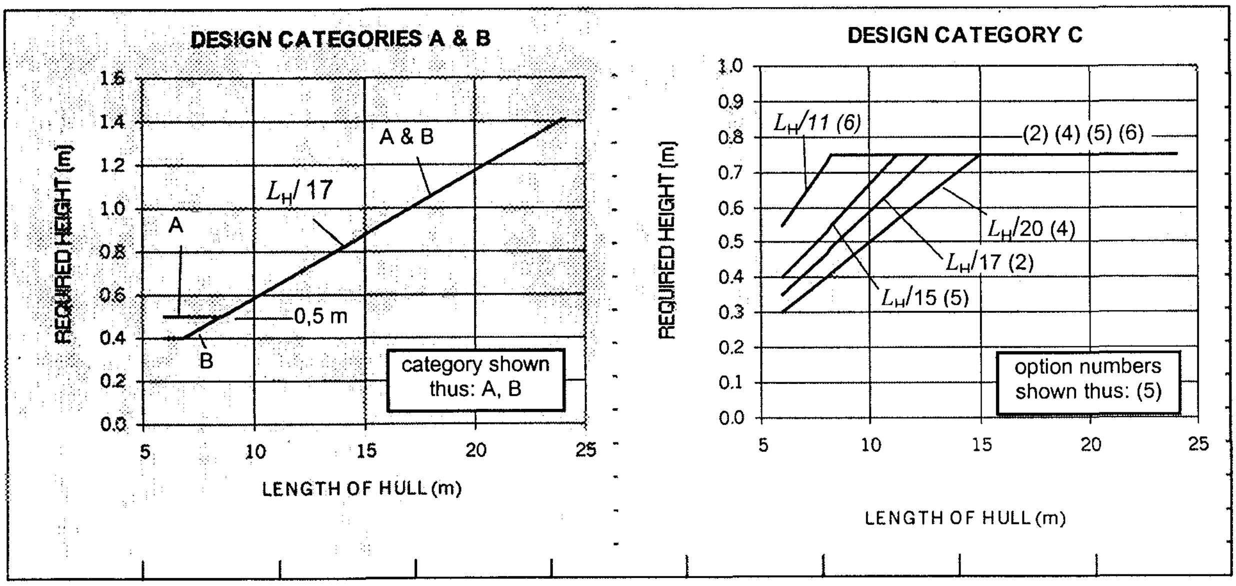


Figure 2 — Required downflooding height — Design categories A, B and C

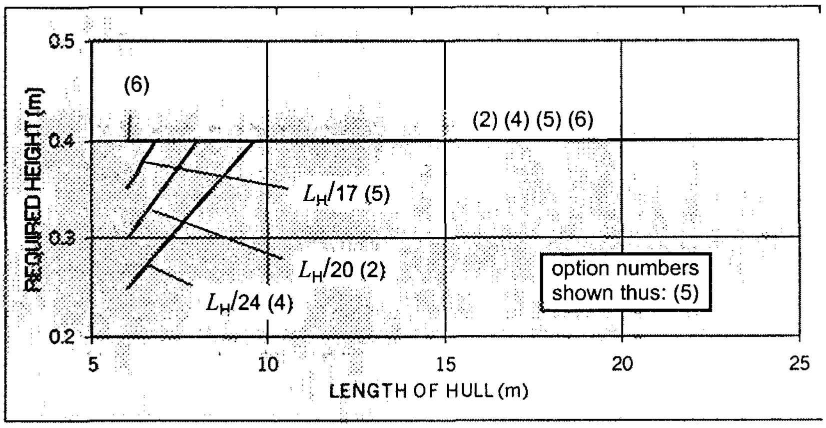


Figure 3 — Required downflooding height — Design category D

b) For boats assessed using options 3, 4 or 6, the required downflooding height within L_H /3 of the bow shall be increased as shown in Figure 4.

c) Boats assessed using options 3 or 4 are permitted a 20 % reduction in required downflooding height in way of an outboard engine mounting position, provided that the width of the area where this reduction applies is minimized.

d) Boats assessed using Figures 2 or 3 shall be permitted downflooding openings having a combined clear area, in square millimetres (mm^2), of not more than (50 $L_H{}^2$) within the aft quarter of L_H provided that the downflooding height to these openings is not less than ¾ of that required by these figures.

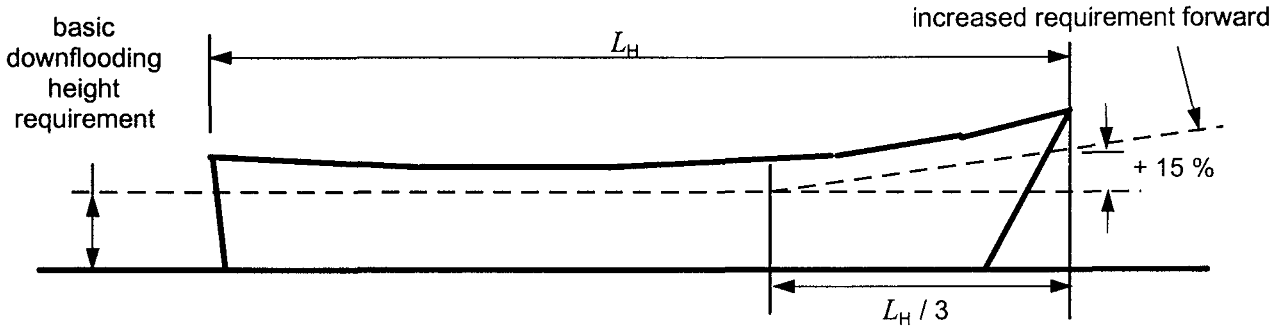


Figure 4 — Increase in required downflooding height — Options 3, 4 and 6

6.1.3 Downflooding angle

This requirement is to show that, when at loaded displacement mass, there is sufficient margin of heel angle before significant quantities of water can enter the boat.

The angle of heel at which downflooding opening(s) having a total combined area, expressed in square millimetres, greater than the number represented by (2 m_{LDC}) first become immersed shall be greater than the requirements given in Table 3 as a function of the offset load heel angle (ϕ_O). Main access companionways shall be considered to be closed.

Table 3 — Downflooding angle requirements

Design category	Minimum downflooding angle (degrees)	
	options 1 to 5, use whichever is the greater	
A	$\phi_O + 25$	30
B	$\phi_O + 15$	25
C	$\phi_O + 5$	20
D	ϕ_O	

Where a downflooding opening is protected by a higher coaming around the recess from which it leads, the downflooding angle shall be determined to the lowest point of that coaming.

The downflooding angle (ϕ_D) may be determined using any one of the methods in Annex C.

6.2 Offset load test

This test is to demonstrate sufficient stability for the boat at loaded displacement mass against offset loading by the crew.

Conduct the offset load test in accordance with Annex B using either physical test or calculation methods, thus obtaining the offset load heel angle ϕ_O.

For all design categories the heel angle ϕ_O shall not be greater than

$$\phi_{O(R)} = 10 + \frac{(24 - L_H)^3}{600}$$ - see Table 4.

Table 4 — Maximum heel angle for offset load test

L_H (m)	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0	21,0	24,0
$\phi_{O(R)}$ (°)	19,7	18,2	16,8	15,6	14,6	12,9	11,2	10,4	10,0	10,0

In addition, for boats using option 6, during this test the least height from the waterline to the point at which water could first begin to enter the interior of the boat shall exceed

a) $0{,}11 \sqrt{L_H}$ for boats of design category C, or

b) $0{,}07 \sqrt{L_H}$ for boats of design category D.

6.3 Resistance to waves and wind (design category A and B monohulls only)

Monohull boats shall be assessed using 6.3.1 and 6.3.2. This clause shall not be applied to multihull boats.

6.3.1 Rolling in beam waves and wind

The curve of righting moments of the boat at loaded displacement mass shall be established to the downflooding angle or the angle of vanishing stability, or 50° whichever is least using any of the methods of Annex D

The wind heeling moment, M_W, is assumed to be constant at all angles of heel and shall be calculated as follows:

$$M_W = 0{,}3\, A_{LV} (A_{LV}/L_{WL} + T_M)\, v_W^2 \text{ (Nm)}$$

where

T_M is the draught at the mid-point of the waterline length, expressed in metres;

v_W = 28 m/s for design category A, and 21 m/s for design category B.

Alternatively, the wind heeling characteristics may be determined from wind tunnel tests.

Calculate the assumed roll angle ϕ_R:

ϕ_R = (24 + 10/ V) for design category A, and (19 + 15/ V) for design category B.

Plot the righting moment curve and the wind heeling moment on the same graph as shown in Figure 5. Area A_2 shall be greater than area A_1, where A_1 and A_2 are the areas indicated in Figure 5.

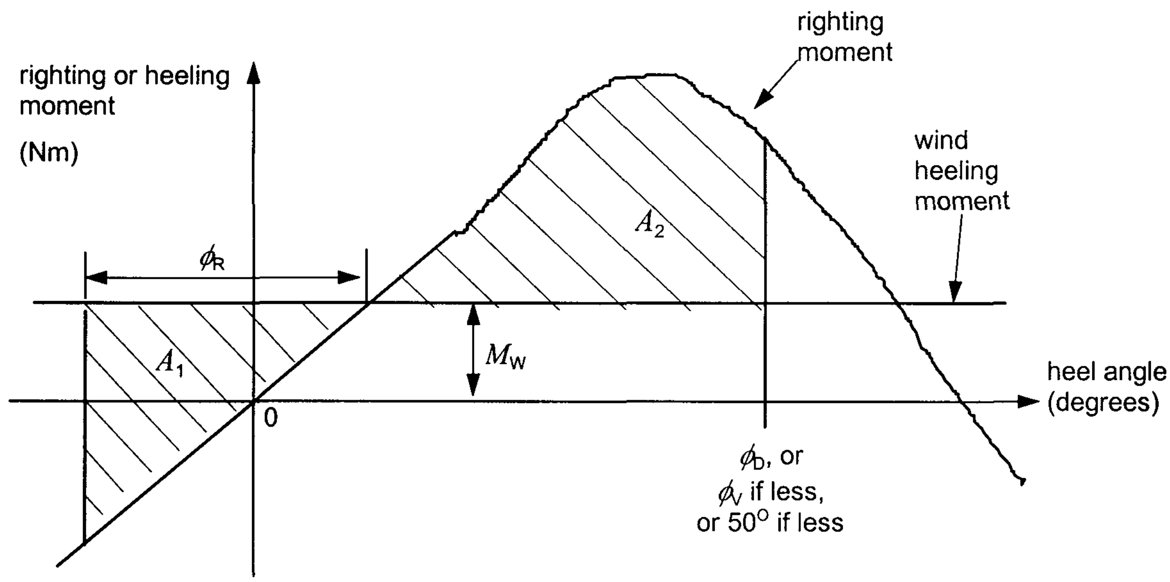


Figure 5 — Roll resistance to waves and wind

6.3.2 Resistance to waves

In addition to the requirements of 6.3.1, the curve of righting levers at angles of heel up to ϕ_D or ϕ_V or 50° whichever is the least shall comply with the following.

a) Maximum righting lever shall occur at a heel angle of not less than 15°;

b) If maximum righting lever occurs at a heel angle of 30° or more, then the value of the righting lever at an angle of 30° or more shall exceed

1) 0,20 m for design category A;

2) 0,14 m for design category B.

c) If maximum righting lever occurs at a heel angle of 15° or more, but less than 30°, then the boat shall have an area under the curve of righting levers, from 0° up to the angle of maximum righting lever of not less than

1) [3.15 + 0.057(30 - ϕ_{GZmax})] (metre-degrees) for design category A;

2) [2.20 + 0.040(30 - ϕ_{GZmax})] (metre-degrees) for design category B,

where

ϕ_{GZmax} is the angle in degrees at which maximum righting lever occurs.

6.4 Heel due to wind action (design categories C and D only)

Boats of design category C and D where $A_{LV} < (L_H B_H)$ do not have to be assessed. Other boats shall be assessed as follows:

The wind heeling moment (M_W) shall be calculated as in 6.3.1, but using:

v_W = 17 m/s for design category C, and 13 m/s for design category D

The heel angle due to the wind heeling moment, ϕ_W, shall be determined either by comparing the heeling moment with the curve of righting moments or from the formula:

$$\phi_W = (M_W / M_C) \times \phi_O$$

where

M_C is the the maximum offset load moment, expressed in Newton-meters, due to crew from Annex B;

ϕ_O is the offset load heel angle observed due to M_C.

The angle ϕ_W shall be less than ($0,5 \times \phi_{O(R)}$) derived from 6.2.

6.5 Flotation test

This test is to demonstrate adequate swamped buoyancy and stability, and shall be performed using the method given in Annex E. Where flotation material or elements are used, they shall comply with Annex F.

7 Application

7.1 Deciding the design category

The design category finally given in respect of stability and buoyancy is that for which it complies with **all** the requirements appropriate to the boat as required by 5.3 and Clause 6.

7.2 Meaning of the design categories

7.2.1 A boat given design category A is considered to be designed to operate in waves up to 7 m significant height and winds Beaufort force 10 or less, and to survive in more severe conditions. Such conditions may be encountered on extended voyages, for example across oceans, or inshore when unsheltered from the wind and waves for several hundred nautical miles. Winds are assumed to gust to 28 m/s.

NOTE This is intended to correspond to design category A of the EU Recreational Craft Directive.

7.2.2 A boat given design category B is considered to be designed for waves up to 4 m significant height and a wind of Beaufort force 8 or less. Such conditions may be encountered on offshore voyages of sufficient length or on coasts where shelter may not always be immediately available. These conditions may also be experienced on inland seas of sufficient size for the wave height to be generated. Winds are assumed to gust to 21 m/s.

NOTE This is intended to correspond to design category B of the EU Recreational Craft Directive.

7.2.3 A boat given design category C is considered to be designed for waves up to 2 m significant height and a typical steady wind force of Beaufort force 6 or less. Such conditions may be encountered on exposed inland waters, in estuaries, and in coastal waters in moderate weather conditions. Winds are assumed to gust to 17 m/s.

NOTE This is intended to correspond to design category C of the EU Recreational Craft Directive.

7.2.4 A boat given design category D is considered to be designed for waves up to 0,3 m significant height with occasional waves of 0,5 m height and a typical steady wind force of Beaufort force 4 or less. Such conditions may be encountered on sheltered inland waters, and in coastal waters in fine weather. Winds are assumed to gust to 13 m/s.

NOTE This is intended to correspond to design category D of the EU Recreational Craft Directive.

Table 5 — Summary of design category definitions

Design category	A	B	C	D
Significant wave height up to (m)	7	4	2	0,3
Typical beaufort wind force	up to 10	up to 8	up to 6	up to 4
Calculation wind speed (m/s)	28	21	17	13

7.2.5 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.

Annex A
(normative)

Full method for required downflooding height

The required downflooding height may be calculated according to the following instead of using Figure 2. In all cases the following limits apply:

Table A.1 — Limits on required downflooding height

Dimensions in metres

Design category	A	B	C	C	D	D
Options	1	1,3	2, 4, 5	6	2, 4, 5	6
$h_{D(R)}$ shall not be less than	0,5	0,4	0,3	0,5	0,2	0,4
$h_{D(R)}$ shall not be more than	1,41	1,41	0,75	0,75	0,4	-

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

$$h_{D(R)} = H_1 \times F_1 \times F_2 \times F_3 \times F_4 \times F_5$$

where

H_1 $= L_H / 15$;

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

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

$F_1 = (1 - x_D / L_H)$ or $(1 - y_D / B_H)$ whichever is greater, see Figure A.1

where

x_D is the longitudinal distance of a downflooding opening not fitted with closure complying with ISO 12216 from the tip of the stem or stern (whichever is less);

y_D is the least transverse distance of a downflooding opening not fitted with closure complying with ISO 12216 from the periphery of the boat.

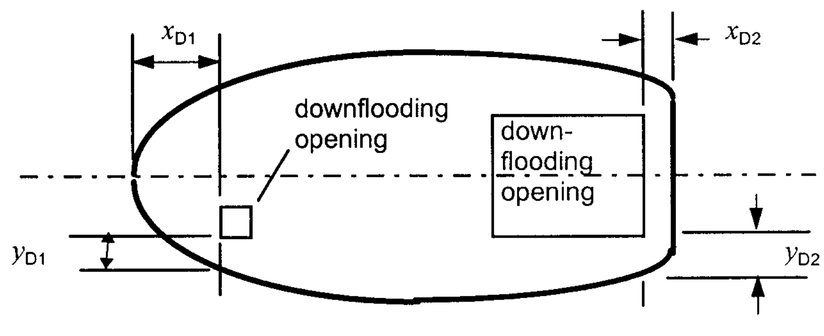


Figure A.1 — Dimensions x_D and y_D

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

$F_2 = 1{,}0$ if $a \geq (30\,L_H)^2$

where

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

$$F_2 = 1 + \frac{x_D'}{L_H}\left[\frac{\sqrt{a}}{7{,}5L_H} - 0{,}4\right] \text{ if } a < (30\,L_H)^2$$

where

x_D' is the longitudinal distance of the opening from the tip of the stern.

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 recess is quick-draining:

$F_3 = (0{,}7 + k^{0{,}5})$

where

$k = V_R / (L_H\, B_H\, F_M)$

where

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

F_4 is the **displacement factor** (varies between about 0,7 and 1,1):

$$F_4 = \left[\frac{10\nabla}{L_H B^2}\right]^{1/3}$$

where

∇ is the volume of displacement in loaded displacement condition, $= m_{LDC} / 1025$;

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, and = 1,0 for all other boats.

Annex B
(normative)

Method for offset load test

B.1 Objective

The objective is to determine the heel angle attained when the maximum recommended number of people on board (crew limit) are crowded to one side.

B.2 Means of determination

The angle may be determined in any of the following ways:

a) physical test. For the purposes of this test, any downflooding openings immersed before the downflooding angle may be temporarily sealed;

b) calculation with supporting tests, but including separate additional margins to allow for errors - see D.2;

c) calculation using supporting information from an inclining experiment.

Details of the application of these alternatives are given below.

B.3 Method

The boat shall be at the loaded displacement mass.

B.3.1 Basic method for boats with one deck level

a) Calculate CD from the formula:

$$CD = \frac{CL}{4A_C}$$

where

CL is the crew limit;

A_C is the the crew area, being the area of deck or cockpit intended by the manufacturer for the use of the crew when the craft is underway, being any area where people may stand, sit, walk or lie, and where any of the following activities may take place:

- craft manoeuvring and steering;
- access to outside or inside accommodation;
- recreation;
- handling or trimming of any sails.

The area A_C shall not include

- windscreens;
- wheelhouse tops unless equipped for crew use;

— any areas inclined at more than 10° to the waterline at loaded displacement mass and design trim;

— areas only intended by the manufacturer to be used when at slow speed preparatory to anchoring or mooring, e.g. areas of decking less than 200 mm wide.

NOTE On smaller craft such as dayboats, the area A_C may be limited to the cockpit.

b) Calculate the expected maximum heeling moment due to crowding of the crew, M_C, from:

if $CD \geq 0{,}5$ then $M_C = 314 \times A_C \times B_C$ (in Newton-metres)

if $CD < 0{,}5$ then $M_C = 314 \times CL \times B_C \times (1 - CD)$ (in Newton-metres)

where

B_C is the transverse distance between the maximum extremities of the area A_C.

c) Apply the heeling moment, M_C, to the boat and measure the heel angle (ϕ_O).

NOTE B.4 details the application of M_C by physical test, and B.5 details the application of M_C by calculation.

d) When applying the heeling moment, the vertical position of the centre-of-gravity of the crew may be represented as though they are ballast weights placed on top of seats, or on the deck where the people are assumed to be standing.

B.3.2 Method for boats with more than one deck level

Where a boat has more than one deck level on which crew may be accommodated, the following procedure shall be employed.

a) Assume that the highest level is occupied by the maximum number of people (N_1) that does not exceed two for each square metre of the crew area (as defined in B.3.1) at this deck level (A_{C1}).

NOTE 1 If the manufacturer limits the number of persons assumed to be located on flying bridges or coachroofs to less than that described above, this number may be employed in this calculation, provided that the respective limit is clearly marked at all points of access to that level.

b) Calculate CD_1 and M_{C1} for this level, using the method of B.3.1, using the value of B_C appropriate to that level (B_{C1}).

c) Assume that the next highest level is occupied by the maximum number of people (N_2) that does not exceed two for each square metre of the crew area at this deck level (A_{C2}), remembering that $N_2 \leq (CL - N_1)$.

d) Calculate CD_2 and M_{C2} for this level, using the method of B.3.1, using the value of B_C appropriate to that level (B_{C2}).

e) Assume that the next highest level is occupied by the maximum number of people (N_3) that does not exceed two for each square metre of the crew area at this deck level (A_{C3}), remembering that $N_3 \leq (CL - N_1 - N_2)$.

f) Calculate CD_3 and M_{C3} for this level, using the method of B.3.1 using the value of B_C appropriate to that level (B_{C3}).

g) Repeat e) and f) as necessary until $N_1 + N_2 + N_3 + .. + N_N = CL$.

h) Calculate $M_C = M_{C1} + M_{C2} + M_{C3} + .. + M_{CN}$.

i) Apply the heeling moment, M_C, to the boat and measure the heel angle (ϕ_O).

NOTE 2 B.4 details the application of M_C by physical test, and B.5 details the application of M_C by calculation.

j) When applying the moment M_C to the boat, the vertical position of the centre-of-gravity of the boat plus maximum total load shall reflect the vertical distribution of the crew used in calculating M_C, considering that the vertical position of the centre-of-gravity of the crew may be represented as though they are ballast weights placed on top of seats, or on the deck where the people are assumed to be standing.

B.3.3 Additions of top-weight

Because additions of top-weight may dramatically affect ϕ_O, it is important that the test and/or calculations should be undertaken for any boat that deviates substantially from the standard outfit. In particular, masts, radar antennae, equipment and sail furling gear may significantly affect the stability. The effects of such variations from a boat on which a test has been performed, may be determined by calculation using the mass and co-ordinates of the variations.

A significant deviation from the standard outfit shall be assumed to have occurred if:

$$\Sigma(m, h) > 0{,}02\ B_H\ m_{LDC}$$

where

$\Sigma(m, h)$ is the sum for all variations from the standard outfit of the product of the mass of the component and its height above the waterline.

B.4 Application of M_C by physical test

Test weights or persons may be used to represent the mass of the crew. Where persons are used their average mass shall be ≥ 75 kg. If standing they should stand with feet together and maintain their balance without using handholds.

When the position for the test weights or persons that result in the heeling moment M_C required by clause B.3 has been found, the heel angle shall be measured. The test shall then be repeated with the boat heeling in the other direction. The greater of the two measured heel angles shall be taken as the value of ϕ_O for the purposes of this part of ISO 12217.

When recording the heel angle of the boat, people engaged in measuring the heel angle shall return to the same position on board each time measurements are recorded.

Care should be taken during the test to avoid capsize or sinking.

B.5 Application of M_C by calculation

The heel angle resulting from the offset load may be calculated as set out below.

a) Calculate the curve of righting moments for the boat for a range of relevant heel angles using the methods of Annex D.

b) Calculate the heeling moment curve as follows:

$$M_{C\phi} = M_C \cos \phi$$

where

$M_{C\phi}$ is the heeling moment at a heel angle ϕ

c) The offset load test heel angle (ϕ_O) is the angle nearest the upright at which the curve of righting moments and the curve of heeling moments intersect.

Annex C
(normative)

Methods for calculating downflooding angle

Any of the following methods may be used.

C.1 Theoretical calculation

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

C.2 Approximate method for downflooding angles up to 60°

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

$$\phi_D = \tan^{-1} (z_D / y_D')$$

ϕ_D = [the angle whose tangent is (z_D / y_D')]

where

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

y_D' is the transverse distance, expressed in metres, of the downflooding point from the centreline of the craft.

See Table C.1 and Figure C.1.

Table C.1 — Approximate method for downflooding angle

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

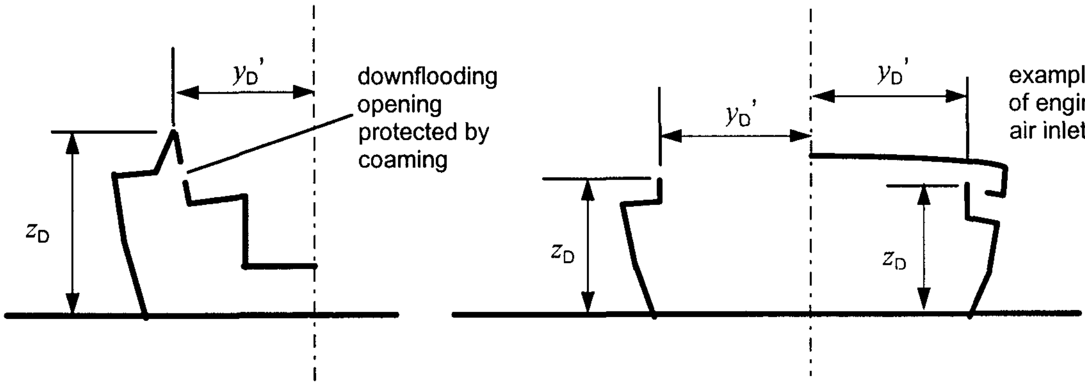


Figure C.1 — Approximate method for downflooding angle

C.3 Improved approximate method for large downflooding angles

Suitable for downflooding angles in the range 50° to 100°, and especially for openings which are inboard from the periphery of the boat.

a) Before using this method, check that ϕ_O > 50° using C.2.

b) Calculate

$$C_{d\,60} = 0{,}577z_D + 0{,}5B_{WL} - Q - X_2$$

where

Q = 0,5774F;

F = 0,25(F_F + 2F_M + F_A);

F_F is the freeboard to deck forward;

F_M is the freeboard to deck midships;

F_A is the freeboard to deck aft;

X_2 $= (C_7^2 - C_8)^{0.5} - C_7;$

C_7 $= (0{,}325F + Qk)/k;$

C_8 $= (0{,}333bF + 0{,}4QF + kQ^2 - 0{,}000985m_{LDC}/L_M) / k;$

k $= 0{,}2165 \text{ sine } \alpha / \text{sine } \beta;$

α $= \tan^{-1} (2T_C / B_{WL});$

β $= 60° - \alpha;$

b $= (B_H - B_{WL})/2;$

T_C is the draught of the canoe body according to ISO 8666;

L_M $= (L_H + L_{WL})/2.$

c) Calculate

$$C_{d.90} = 0{,}5 B_{WL} - X_1$$

where

X_1 $= [(C_5 / C_4)^2 - C_6 / C_4]^{0.5} - C_5 / C_4;$

C_4 $= 0{,}1 T_C / B_{WL};$

C_5 $= 0{,}3268 F;$

C_6 $= 0{,}35 F(B_H - B_{WL}) - 0{,}000985 m_{LDC} / L_M;$

d) Calculate

$$\phi_D = 60 + \frac{30(C_{d.60} - y_D')}{(C_{d.60} - C_{d.90})}$$

Annex D
(normative)

Determining the curve of righting moments

D.1 Method

The curve of righting moments can be determined using any of the methods described in D.3, D.4 or D.5. In all cases the mass and centre-of-gravity used shall conform to D.2.

D.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.

D.2.1 Mass

The mass used shall be the loaded displacement mass, and can be found using any of the following methods:

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

b) calculation from the lines plan using a waterline observed on a craft 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 loaded displacement mass;

c) calculation based on the mass of a closely similar vessel 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 light craft condition is less than 10 %.

D.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 3.5.6), the results being corrected to the loaded displacement 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 loaded displacement condition;

c) calculation based on the calculated mass and centres of gravity of individual components, raised by an addition of 5 % of the structural depth (as defined in ISO 8666).

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

For the purposes of determining the curve of righting moments, the vertical disposition of the mass of the crew shall be that used in the offset load test as described in Annex B.

D.2.3 Longitudinal centre-of-gravity

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

a) methods (b) or (c) in D.2.1;

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

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

D.3 Determination by rigorous calculation

D.3.1 The curve of righting moments 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 necessary 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 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.

D.3.2 In defining the watertight hull: cockpits, recesses, bow thruster tunnels and all appendages affecting the buoyancy shall be correctly represented.

D.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 of at least 90°.

D.3.4 The buoyancy of masts and standing rigging (but not booms, gaffs, or running rigging) may be included in the calculation of righting moment if desired. In this case only the buoyant volume is to 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.

D.4 Determination by experiment

The curve of righting moments can be found from a practical experiment. Because of the physical difficulties, this would usually only be considered appropriate for satisfying the requirements of the offset load test (6.2) or the heel angle due to wind (6.4).

D.5 Determination by approximate calculation method (undergoing validation)

An approximation to the curve of righting moments can be obtained for monohulls without a lines plan using the following procedure. This method assumes that recesses and superstructures are both of very moderate extent.

The righting moment (M_ϕ) (kN m) at any heel angle ϕ (degrees) is given by:

$$M_\phi = 0{,}009806\ GZ_\phi\ m_{\text{LDC}}$$

where

GZ_ϕ is the approximate righting lever, in metres, at any heel angle ϕ, in degrees, which is given by:

$$GZ_\phi = 0{,}9\ (OB + BM_\phi - OG) \sin\phi$$

$$GZ_\phi = 0 \text{ when } \phi = 0° \text{ or } 180°$$

Over the range of ϕ from 0° to 10° GZ_ϕ is approximately given by:

$$GZ_\phi = GM \sin\phi$$

where

OB is the depth of centre of buoyancy below the waterline, expressed in metres (always a negative number);

BM_ϕ is the height of transverse metacentre above the centre of buoyancy, expressed in metres (m), which varies with heel angle;

OG is the height of the centre of gravity, positive above the waterline, negative below;

GM is the transverse metacentric height;

ϕ is the heel angle.

OB is approximately given by:

$$OB = -[\,0{,}1577 + C_B / (3\,C_{WP})\,]\,T_C$$

where

C_B is the block coefficient of the canoe body (i.e. hull without keel, deadwood or rudder):

$$C_B = m_{LDC} / (1025\,L_{WL}\,B_{WL}\,T_C);$$

C_{WP} is the waterplane area coefficient:

$$C_{WP} = A_W / (L_{WL}\,B_{WL})$$

where

A_W is the area of waterplane, in square metres.

If the area of the waterplane is not known:

C_{WP} = 0,75 if boat has a transom stern which is immersed at loaded displacement mass,
= 0,65 in other cases.

OG can either be determined from an inclining experiment, or by calculation, see D.2.2. If the inclining experiment method is used, the metacentric height is found from the expression:

$$GM_E = M_E / (m_E \sin \phi_E)$$

where

GM_E is the metacentric height derived from the experiment;

M_E is the heeling moment, in kilograms per metre, applied during the experiment;

m_E is the mass of the boat during the experiment;

ϕ_E is the heel angle measured when the moment M_E is applied.

Then

$$OG_E = BM_0 + OB - GM_E$$

where

OG_E is the height of the centre-of-gravity above the waterline in the inclining experiment condition;

NOTE 1 This may require to be corrected to the centre-of-gravity of the loaded displacement condition.

BM_0 is the value of BM_ϕ at 0° heel.

An approximate expression for BM_ϕ is:

$$BM_\phi = C_1 \times B_{WL}^2 / T_C$$

where

C_1 is obtained from Table D.1;

D is the depth of hull from bottom of canoe body to the lowest point of the deck at side of hull;

C_{WP} is the waterplane area coefficient, as above;

C_P is the prismatic coefficient of the canoe body:

$$C_P = m_{LDC} / [1025\, L_{WL}\, A_M]$$

where

A_M is the area of midship section area below waterline to draught T_C, in square metres (m^2).

C_P = 0,65 if A_M is not known.

Other symbols are as given in clause 4.

NOTE 2 The expressions for C_1 are valid for hull forms with hull geometry ratios in the following ranges:

— (B_{WL} / T_C) between 3,3 and 8,5;

— (D / T_C) between 1,2 and 3,9;

— (B_H / B_{WL}) between 1,0 and 1,2.

Further work is being carried out to check these relationships for a wider range of hull forms.

Table D.1 — Values of coefficient C_1

For ϕ (degrees)	Coefficient C_1 is given by
0	$C_1 = (0,0703\, C_P + 0,0104\, C_P^2\, C_{WP}^2) / C_B$
20	$C_1 = 0,114 + 0,751 / R_1^2 - (0,008086\, R_1)^2 - 0,0144 / R_2^2 - 0,0585 / (R_2\, R_3) - (0,03042\, R_3)^2$
40	$C_1 = 0,104 + 1,208 / R_1^2 - (0,008419\, R_1)^2 + 0,0124 / R_2^2 - 0,172 / (R_2\, R_3) - (0,04418\, R_3)^2$
60	$C_1 = 0,105 + 1,297 / R_1^2 - (0,003052\, R_1)^2 + 0,0057 / R_2^2 - 0,204 / (R_2\, R_3) - (0,05116\, R_3)^2$
80	$C_1 = 0,099 + 0,101 / R_1^2 - (0,02663\, R_1)^2 - 0,0124 / R_2^2 - 0,0733 / (R_2\, R_3) + (0,02119\, R_3)^2$
NOTE 1 $R_1 = (B_{WL} / T_C)$ NOTE 2 $R_2 = (B_H / B_{WL})$ NOTE 3 $R_3 = (D / T_C)$	

Annex E
(normative)

Method for level flotation test

The following method shall be used, either by actual test or equivalent calculation:

E.1 Test condition

During the tests the boat shall be in calm water in the light craft condition and then equipped as follows.

a) A mass equal to 25 % of the dry mass of stores and equipment included in the maximum total load shall be added.

b) Vulnerable items such as engines shall be replaced with an appropriate mass at the correct location.

c) For outboard engines, the builder's maximum recommended power shall be used. Tables E.2 and E.3 columns 2 and 4 give the appropriate replacement mass to be used with respect to engine power for petrol engines. A heavier mass may be used if it is recorded in the owner's manual. A mass of 86 % of the engine dry mass shall be used for diesel, jet-propulsor or electric outboards, if these are supplied as the standard outfit. Boats equipped for use both with and without an outboard engine shall be tested in both conditions.

d) For inboard engines the replacement mass shall be solid steel or iron of a mass equal to 75 % of the installed engine dry mass.

e) Replacement masses shall as far as practicable have the same position of centre-of-gravity as the actual engine.

f) Portable fuel tanks shall be removed, fixed tanks shall either be full of fuel, or have an equivalent mass added, for example by filling with the same mass of water.

g) All cockpit and similar drains normally open during operation of the boat shall be left open. The plugs of drains for emptying the boat of residual water when ashore shall be in place.

h) Care shall be taken throughout the testing to eliminate entrapped air other than in air tanks or air containers.

i) Void compartments integral with the boat structure and not complying with the requirements for air tanks in Annex F shall be opened so that they become swamped with water.

j) Boats intended to be fitted with engines of more than 3 kW and which are fitted with integral air tanks which have laminated, glued, welded or bolted seams in their construction, and which air tanks do not comply with the enhanced pressure test of Annex F, shall have a number of air chambers opened to atmosphere during testing, according to Table E.1.

Table E.1 — Numbers of air chambers to be opened

Total number of air tanks	Number to be opened
≤ 4	single largest
> 4 but ≤ 8	two largest
> 8	three largest

Table E.2 — Mass of single engine installations

Engine power (kW)	Motor + Controls (kg)		Battery (kg)	
column	1	2	3	4
	dry	swamp	dry	swamp
0 to 1,9	13,0	11,2	-	-
2,0 to 3,6	23,0	19,8	-	-
3,7 to 5,8	32,0	27,5	-	-
5,9 to 6,9	42,0	36,1	9,1	5,0
7,0 to 13,9	54,0	46,4	20,4	11,3
14,0 to 17,9	63,0	54,2	20,4	11,3
18,0 to 28,9	82,0	70,5	20,4	11,3
29,0 to 43,9	121,0	104,1	20,4	11,3
44,0 to 54,9	157,0	135,0	20,4	11,3
55,0 to 83,9	187,0	160,8	20,4	11,3
84,0 to 186,0	235,0	202,1	20,4	11,3
186 and over	257,0	221,0	20,4	11,3

Table E.3 — Mass of twin engine installations

Total engine power (kW)	Motor + Controls (kg)		Battery (kg)	
column	1	2	3	4
	dry	swamp	dry	swamp
28,0 to 35,9	126,0	108,4	40,8	22,7
36,0 to 57,9	164,0	141,0	40,8	22,7
58,0 to 87,9	242,0	208,1	40,8	22,7
88,0 to 109,9	314,0	270,0	40,8	22,7
110,0 to 167,9	374,0	321,6	40,8	22,7
168,0 to 372,0	470,0	404,2	40,8	22,7
372,0 and over	514,0	442,0	40,8	22,7

Informative Note:

(power in kW) = (imperial horsepower) x 0,7457

(imperial horsepower) = (power in kW) x 1,341

E.2 Swamped stability test

a) A metallic test weight with a dry mass of ($6dCL$) kg but not less than ($15d$) kg shall be suspended over the side of the boat at each of four positions in turn. These positions shall be at $L_H/3$ from the ends of the boat (as shown in Figure E.1) or at the ends of the cockpit if this is nearer amidships. No other test weights shall be in the boat during this test.

b) d is a coefficient to account for the buoyancy of the test weight, as given in Table E.4. Where test weights are not all of the same material, then the calculation should be similar to

$$m_L / 1,098 + m_{CI} / 1,161 + m_A / 1,601 = 6\,CL$$

where

m_L is the mass of lead weights, expressed in kilograms;

m_{CI} is the mass of cast iron weights, expressed in kilograms;

m_A is the mass of aluminium weights, expressed in kilograms;

c) As an alternative to suspending a test weight over the side, an equivalent heeling moment (calculated when the boat is upright) may be applied using weights or persons positioned inside the boat at seat level.

d) With the test weight in each position in turn, swamp the boat by applying a downwards force at a position on the gunwale at approximately mid L_H until the deepest point of the gunwale or coaming is between 0,1 m and 0,3 m below the water surface. Hold the boat in this position until the water level has equalised between inside and outside, or for five minutes, which ever is less, and then release the boat.

NOTE It is often helpful to partially fill the boat with water before swamping in this manner.

e) For each position of the test weights, after a further five minutes have elapsed, the boat shall not heel more than 45°.

Table E.4 — Material coefficient

Material	Lead	65/35 brass	Steel	Cast iron	Aluminium
Value of d	1,098	1,136	1,148	1,161	1,601

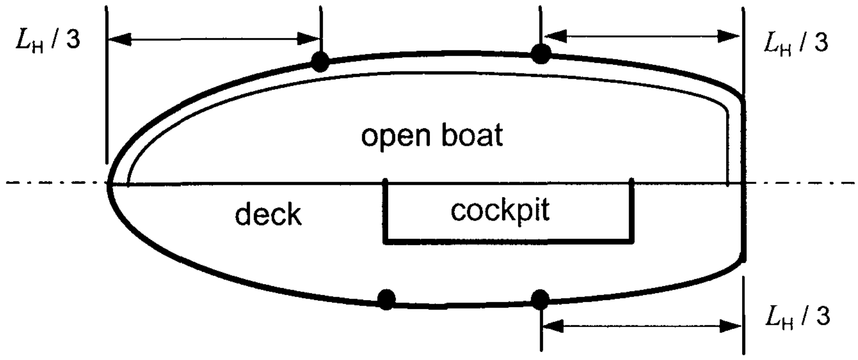


Figure E.1 — Positioning test weights

E.3 Swamped buoyancy tests

The boat shall satisfy both the One Person Test and the Load Test, as described below.

E.3.1 One person test

a) Load metallic test weights with a dry mass of $75\,d$ on the inner bottom of the boat. Alternatively one person with a mass not less than 75 kg may be used instead of test weights. This mass may be located at any longitudinal position needed to satisfy (c) below.

b) Swamp the boat by applying a downwards force at a position on the gunwale at approximately mid L_H until the deepest point of the gunwale or coaming is between 0,1 m and 0,3 m below the water surface. Hold the boat in this position until the water level has equalised between inside and outside, or for five minutes, which ever is less, and then release the boat.

NOTE It is often helpful to partially fill the boat with water before swamping in this manner.

c) After a further five minutes have elapsed, the boat shall float such that the residual freeboard would enable it to be pumped or bailed out.

E.3.2 Load test

a) Load metallic test weights on the inner bottom of the boat, evenly about the centre of the area available to the crew, according to the crew limit (CL) as given in Table E.5. This area shall have a minimum headroom clearance of 0,6 m above the swamped waterline. Alternatively people to the crew limit (with an average mass not less than 75 kg) may be used instead of test weights.

Table E.5 — Mass of load test weights

	Design category B	Design category C	Design category D
Dry mass (kg) not less than	$4\,d\,m_{MTL}/3$	$d\,(60 + 15\,CL)$	$d\,(50 + 10\,CL)$

b) Swamp the boat by applying a downwards force at a position on the gunwale at approximately mid L_H until the deepest point of the gunwale or coaming is between 0,1 m and 0,3 m below the water surface. Hold the boat in this position until the water level has equalised between inside and outside, or for five minutes, which ever is less, and then release the boat.

NOTE 1 It is often helpful to partially fill the boat with water before swamping in this manner.

c) After a further five minutes have elapsed, the boat shall float approximately level with more than two thirds of the length of the top of the gunwale or coamings (including those across bow or stern) above water.

NOTE 2 The values of the formulae given in E.2 (a) and E.3.2 (a) are given in Table E.6.

Table E.6 — Mass of test weights

Mass in kilograms

Crew limit (CL)		1	2	3	4	5	6	7	8	9	10
$6\,d\,CL$, min $15\,d$	=	$15\,d$	$15\,d$	$18\,d$	$24\,d$	$30\,d$	$36\,d$	$42\,d$	$48\,d$	$54\,d$	$60\,d$
$d(60 + 15\,CL)$	=	$75\,d$	$90\,d$	$105\,d$	$120\,d$	$135\,d$	$150\,d$	$165\,d$	$180\,d$	$195\,d$	$210\,d$
$d(50 + 10\,CL)$	=	$60\,d$	$70\,d$	$80\,d$	$90\,d$	$100\,d$	$110\,d$	$120\,d$	$130\,d$	$140\,d$	$150\,d$

Annex F
(normative)

Flotation material and elements

F.1 Requirements

Flotation elements as defined in clause 3 shall comply with the requirements in Table F.1. Other types of flotation elements shall be evaluated following the same principles. Those materials or parts of the boat which are not primarily intended to provide flotation but which never-the-less contribute to the flotation characteristics shall not be subject to the requirements in this Annex.

Table F.1 — Requirements for flotation elements

Property	Air tank	Air container	Inflated bag	Low density material
Air tightness	RT	RT	R	
Mechanical robustness or protection	R	R	R	R
Draining facility	R	R		
Resistant to or protected from sunlight		R	R	R
Fitted with an inflation point			R	
Temperature resistant – 40°C to + 60°C				R
Water absorption max. 8 % by volume				R
Securely fastened		R	R	R
Encapsulated or resistant to liquids			R	R
Label: 'Do not puncture - air tank/container/bag.'	R	R	R	

NOTE 1 R denotes this property is required but is not subject to a specific test by the builder.

NOTE 2 RT denotes this property is required, and is required to be tested by the builder.

F.2 Tests

Where air tanks or air containers are used, they shall be subject to a pressure test, carried out at an initial over-pressure, with a permitted pressure drop within 30 s, as given in Table F.2.

Table F.2 — Test pressures

	Basic pressure test	Enhanced pressure test
Chambers required to be opened during flotation tests	As detailed in clause E.1(j)	None
Initial over-pressure	1,25 kPa (125 mm water)	2,5 kPa (250 mm water)
Maximum pressure drop in 30 s	0,75 kPa (75 mm water)	1,0 kPa (100 mm water)

Breather holes in air tanks designed for the relief of air pressure due to variations in ambient temperature may be temporarily sealed during the above test, provided that their position does not alter the effectiveness of the tank during the flotation tests of Annex E.

The water absorption of low density material shall not exceed 8 % by volume after being submerged for 8 days according to ISO 2896.

Annex G
(informative)

Summary of requirements

The design category given in respect of stability and buoyancy is that for which the boat satisfies ALL the requirements according to 5.3, as summarised in Table G.1

Table G.1 — Summary of requirements

	OPTION NUMBER	1		2		3	4		5		6	
	DESIGN CATEGORY	A	B	C	D	B	C	D	C	D	C	D
DEGREE OF DECKING OR COVERING	any amount					yes	yes	yes			yes	yes
	partially decked								yes	yes		
	fully decked	yes	yes	yes	yes							
DOWNFLOODING OPENINGS (6.1.1) comply		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
REQUIRED DOWNFLOODING HEIGHT (using figs)	$h_{D(R)}$ >	0,5	0,4	0,353	0,3	0,4	0,3	0,25	0,4	0,353	0,5	0,4
	$h_{D(R)}$ to be >	L_H/17	L_H/17	L_H/17	L_H/20	L_H/17	L_H/20	L_H/24	L_H/15	L_H/17	L_H/11	-
	$h_{D(R)}$ need not be >	1,41	1,41	0,75	0,4	1,41	0,75	0,4	0,75	0,4	0,75	-
DOWNFLOODING HEIGHT (by Annex A)	$h_{D(R)}$ to be >	0,5	0,4	0,3	0,2	0,4	0,3	0,2	0,3	0,2	0,5	0,4
	$h_{D(R)}$ need not be >	1,41	1,41	0,75	0,4	1,41	0,75	0,4	0,75	0,4	0,75	-
DOWNFLOODING ANGLE (6.1.3)	ϕ_D to be > $\phi_{D(R)}$ =	ϕ_O +25	ϕ_O +15	ϕ_O +5	ϕ_O	ϕ_O +15	ϕ_O +5	ϕ_O	ϕ_O +5	ϕ_O	-	-
	(whichever is greater) or	30°	25°	20°	ϕ_O	25°	20°	ϕ_O	20°	ϕ_O	-	-
OFFSET	ϕ_O < $\phi_{O(R)}$ =	10 + $(24 - L_H)^3 / 600$										
LOAD (6.2)	residual freeboard to be >	(not applicable)									$0{,}11\sqrt{L_H}$	$0{,}07\sqrt{L_H}$
ROLLING IN WAVES (6.3.1) (monohulls only)	when v_W (m/s) =	28	21			21						
	$A_2 \geq A_1$ when ϕ_R =	24+10/ ∇	19+15/ ∇			19+15/ ∇						
RESISTANCE TO WAVES (6.3.2) (monohulls only)	ϕ_{GZmax} to be greater than	15°	15°			15°						
	If ϕ_{GZmax} > 30°, GZ_{30} to be >	0,20 m	0,14 m			0,14 m						
	GZ curve area to ϕ_{GZmax} as	6.3.2(c)	6.3.2(c)			6.3.2(c)						
HEEL DUE TO WIND (6.4) only if $A_{LV} > L_H B_H$	when v_W (m/s) =			17	13		17	13	17	13	17	13
	wind heel angle ϕ_W <			$\phi_{O(R)}$/2	$\phi_{O(R)}$/2		$\phi_{O(R)}$/2	$\phi_{O(R)}$/2	$\phi_{O(R)}$/2	$\phi_{O(R)}$/2	$\phi_{O(R)}$/2	$\phi_{O(R)}$/2
LEVEL FLOTATION TEST (6.5)	none required	yes	yes	yes	yes				yes	yes	yes	yes
	required					yes	yes	yes				

Annex H
(informative)

Information for owner's manual

H.1 General information

The following stability information should be included in the owner's manual defined in ISO 10240:

a) A maximum total load = ??? kg has been used for assessing stability and buoyancy comprising

— crew mass (at 75 kg per person)	??? kg
— provisions and personal effects	??? kg
— stores and spare gear	??? kg
— optional additional equipment	??? kg
— inflatable liferaft(s)	??? kg
— other small craft carried aboard	??? kg
— manufacturers maximum recommended load	??? kg
— fuel, fresh water, other fluids to maximum tank capacities	??? kg
maximum total load	??? kg

This assessment has been made assuming that

— the boat in the light craft condition has a mass of	??? kg
— the maximum recommended outboard engine mass is	??? kg
— basic equipment for safe operation	??? kg
— radio and radar equipment	??? kg

— galley and navigation equipment in place,

— mattresses and cushions in place,

— mast(s), boom(s), standard outfit of sails on board,

— all standard equipment is aboard.

NOTE Items are to be included above as appropriate to the boat design.

b) This boat has been given design category ?? with a crew limit of ? in accordance with ISO 12217-1. This category is considered to be designed for use in waves up to ? m significant height and a typical steady wind force of Beaufort force ? or less, subject to

— the crew having suitable skill and experience,

— satisfactory construction and maintenance of the boat and equipment.

c) Users of this boat are advised that

— all crew should receive suitable training,

— the boat should not carry more than the manufacturers maximum recommended load,

— bilge water should be kept to a minimum,

— stability is reduced by any weight added high up,

— in rough weather, hatches, lockers and doorways should be closed to minimise the risk of water ingress,

— stability may be reduced when towing or lifting heavy weights using a davit or boom,

— compartments marked as being air tanks should not be punctured,

— breaking waves are a serious stability hazard.

H.2 Specific information

If appropriate, the following information should be included in the owner's manual.

a) This boat has been assessed as capable of supporting the crew even when swamped *(when meeting the requirements of Annex E.3.2)*.

b) Caution - the stability of this boat is significantly reduced at speeds above ?? knots (or ???? engine rpm).

NOTE Such behaviour can be detected using the method in Annex J.

Annex J
(informative)

Stability at speed under power

J.1 Introduction

Some monohull boats, especially those of round bilge hullform, experience a significant reduction in transverse stability when engine propelled. This may only become apparent at speeds in excess of those given in Table J.1.

Table J.1 — Speed above which a stability reduction can occur

Length of hull (m)	6	8	10	12	15	18	21	24
Speed (knots)	7	8	9	10	12	13	14	15

The method given below enables any tendency to reduced transverse stability to be identified, and any recommendation regarding maximum operating speed to be determined.

J.2 Method

The following test should be conducted twice, both with one crew on board. The first test should be conducted with ballast weights equivalent to the remainder of the maximum load to represent other crew members. The second test should be conducted without these ballast weights. Wind and sea conditions should be as calm as practicable.

a) At zero speed, position the crew (and all the ballast weights if applicable) as far as practicable to one side of the boat whilst remaining within the cockpit and consistent with retaining at least 0,2 m freeboard margin to port or starboard. Note the heel angle.

b) With any wind either directly ahead or astern, accelerate progressively to maximum speed while maintaining a straight course. Observe the progressive change in heel angle. If it begins to increase alarmingly, note the speed at which this occurs and reduce speed immediately.

Repeat (a) and (b) with the crew (and ballast if applicable) moved to the opposite side.

If **either** a sudden increase in heel angle occurs, **or** the heel angle at maximum speed is more than twice that when stationary, a suitable recommendation regarding maximum operating speed should be considered for inclusion in the owner's manual.

Bibliography

[1] ISO 6185–3:—[2], *Small craft — Inflatable boats of less than 8 m with a minimum buoyancy of 1800 N — Part 3: Boats with an engine maximum power rating of 15 kW and greater.*

[2] ISO 10240:1995, *Small craft — Owner's manual.*

[2] To be published.

Annex ZB (informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

By agreement between ISO and CEN, this CEN annex is included in the DIS and the FDIS but will not appear in the published ISO standard.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU Directive 94/25/EC.

WARNING: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

The following clauses of this standard, as detailed in table ZB.1, are likely to support requirements of Directive 94/25/EC.

Compliance with the clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

Table ZB.1: Correspondence between this European Standard and EU Directives

Clauses/sub-clauses of this European Standard	Corresponding annexes/paragraphs of Directive 94/25/EC	Comments
All clauses	3.1 of Annex I, Structure	The standard provides requirements for fibre reinforced plastic construction materials.