INTERNATIONAL STANDARD

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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 — Évaluation et catégorisation de la stabilité et de la flottabilité —

Partie 1: Bateaux à propulsion non vélique d'une longueur de coque supérieure ou égale à 6 m

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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 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12217-1 was prepared by Technical Committee ISO/TC 188, *Small craft*.

This second edition cancels and replaces the first edition (ISO 12217-1:2002), which has been technically revised. It also incorporates the Amendment ISO 12217-1:2002/Amd.1:2009.

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 hull length greater than or equal to 6 m*

— *Part 2: Sailing boats of hull length greater than or equal to 6 m*

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

Introduction

This part of ISO 12217 enables the determination of the limiting environmental conditions for which an individual boat has been designed.

It enables the boat to be assigned to a design category appropriate to its design and maximum load. The design categories used align with those in the Recreational Craft Directive of the European Union, EU Directive 94/25/EC as amended by Directive 2003/44/EC.

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 summarized in Annex I.

Small craft — Stability and buoyancy assessment and categorization —

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

CAUTION — Compliance with this part of ISO 12217 does not guarantee total safety or total freedom of risk from capsize or sinking.

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

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 boats 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 up to 24 m hull length. However, it can also be applied to boats of under 6 m if they do not attain the desired design category specified in ISO 12217-3 and they are decked and have quick-draining recesses which comply with ISO 11812.

In relation to habitable multihulls, this part of ISO 12217 includes assessment of vulnerability to inversion, definition of viable means of escape and requirements for inverted flotation.

This part of ISO 12217 excludes:

— inflatable and rigid-inflatable boats covered by ISO 6185, except for references made in ISO 6185 to specific clauses of ISO 12217;

— personal watercraft covered by ISO 13590 and other similar powered craft;

— gondolas and pedalos;

— sailing surfboards;

— surfboards, including powered surfboards;

— hydrofoils and hovercraft when not operating in the displacement mode; and

— submersibles.

NOTE Displacement mode means that the boat is only supported by hydrostatic forces.

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2896, *Rigid cellular plastics — Determination of water absorption*

ISO 3864-1, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 8666, *Small craft — Principal data*

ISO 9093-1, *Small craft — Seacocks and through-hull fittings — Part 1: Metallic*

ISO 9093-2, *Small craft — Seacocks and through-hull fittings — Part 2: Non-metallic*

ISO 10240, *Small craft — Owner's manual*

ISO 11812, *Small craft — Watertight cockpits and quick-draining cockpits*

ISO 12216, *Small craft — Windows, portlights, hatches, deadlights and doors — Strength and watertightness requirements*

ISO 12217-2:2013, *Small craft — Stability and buoyancy assessment and categorization — Part 2: Sailing boats of hull length greater than or equal to 6 m*

ISO 12217-3:2013, *Small craft — Stability and buoyancy assessment and categorization — Part 3: Boats of hull length less than 6 m*

ISO 14946, *Small craft — Maximum load capacity*

ISO 15083, *Small craft — Bilge-pumping systems*

ISO 15085, *Small craft — Man-overboard prevention and recovery*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE The meanings of certain symbols used in the definitions are given in Clause 4.

3.1 Primary

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

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 reference sail area (3.3.8) $A_S < 0{,}07(m_{LDC})^{2/3}$, where m_{LDC} is the mass of the boat in the maximum load condition, expressed in kilograms

3.1.3
recess
volume open to the air that might retain water within the range of loading conditions and corresponding trims

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

NOTE 1 Cabins, shelters or lockers provided with closures according to the requirements of ISO 12216 are not recesses.

NOTE 2 Cockpits that are open aft to the sea are considered to be recesses. Flush decks without bulwarks or coamings 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 one design category, but not for a higher category.

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 enclosed boat
boat in which the horizontal projection of the sheerline area comprises any combination of

— watertight deck and superstructure, and/or

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

— watertight recesses complying with ISO 11812 with a combined volume of less than $(L_H\ B_H\ F_M)/40$, and

all closing appliances have their degree of watertightness in accordance with ISO 12216

NOTE The size of recesses permitted for boats of design category A, B or some boats of design category C is restricted by the requirements of 6.5.

3.1.7
partially protected boat
boat which does not fulfil the definition of a fully-enclosed boat and in which the plan projected area of decking, cabins, shelters, outboard engine wells or other rigid covers which are watertight from above according to ISO 12216 and which immediately shed water directly overboard (i.e. not via drains) and

— comprises at least one-third of the plan projected area of the sheerline, and

— includes all the area within $L_H/3$ from the bow, and

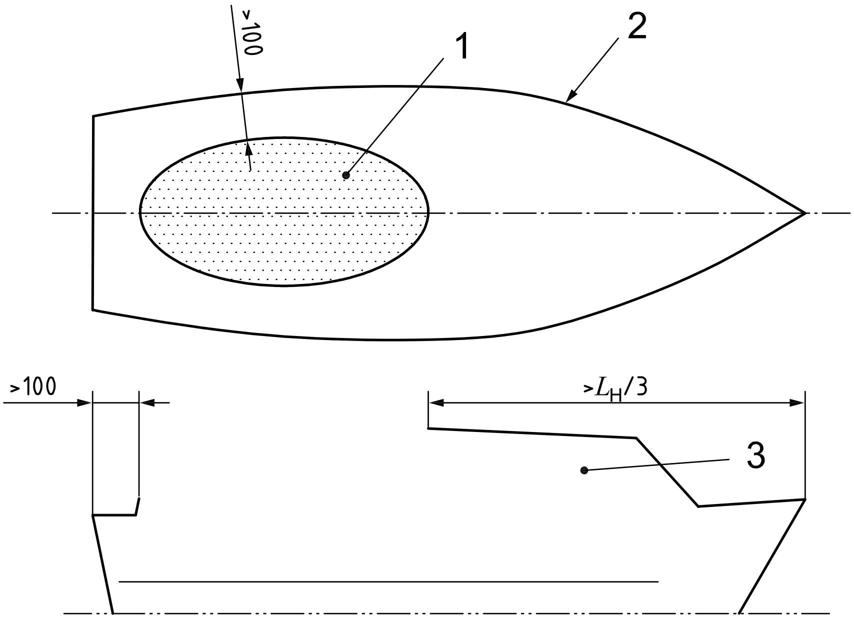
— includes at least 100 mm inboard from the sheerline,

except that the area of any watertight recesses with a total volume of less than $(L_H\ B_H\ F_M)/40$ might shed water via drains

NOTE 1 This is illustrated in Figure 1.

NOTE 2 Outboard engine wells are considered to provide a covering suitable for this purpose.

Dimensions in millimetres



Key

1 recess area open from above (less than two-thirds of total sheerline area)

2 sheerline

3 open shelter or enclosed cabin

Figure 1 — Partially protected boat

3.1.8
habitable boat
boat having a fully enclosed cabin with rigid roof fitted with one or more bunks, benches, pipecots, hammocks or similar locations that can be used for sleeping when the boat is under way

NOTE 1 A boat is considered to be "habitable" if a fabric closure is used instead of a rigid door, or the cabin has fabric sides.

NOTE 2 The following are not considered to render a boat "habitable":

— a cockpit tent, or

— an open-sided cuddy intended to provide limited protection from spray, provided it is not fitted with fabric closures all round.

NOTE 3 Locations used for sleeping have minimum dimensions of 1,5 m diagonal length, 0,4 m width at the widest point, and with a minimum headroom of 0,4 m over the length. The cabin sole and compartments designated by the builder to be used exclusively for storage and referenced in the owner's manual are not included.

3.2 Downflooding

3.2.1
downflooding opening
opening in the hull or deck (including the edge of a recess) that might admit water into the interior or bilge of a boat, or a recess, apart from those excluded in 6.1.1.6

3.2.2
downflooding angle
ϕ_D
angle of heel at which downflooding openings (apart from those excluded in 6.1.1.6) become immersed, when the boat is in calm water and in the appropriate loading condition at design trim

NOTE 1 Where openings are not symmetrical about the centreline of the boat, the case resulting in the smallest angle is used.

NOTE 2 The following are specifically considered:

— ϕ_D is the downflooding angle to any downflooding opening

— ϕ_{DA} is the angle of heel at which openings which are not marked “KEEP SHUT WHEN UNDER WAY” having a combined total area, expressed in square centimetres (cm^2), greater than the number represented by $1{,}2 L_H B_H F_M$ first become immersed;

NOTE 3 Downflooding angle is expressed in degrees.

3.2.3
downflooding height
h_D
smallest height above the waterline to any downflooding opening, apart from those excluded in 6.1.1.6, when the boat is upright in calm water and in the maximum load condition, measured to the critical downflooding point which might be within pipes or ducts inside the hull

NOTE 1 Downflooding height is expressed in metres.

NOTE 2 See Figure D.1 c).

3.3 Dimensions, areas and angles

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

NOTE Length of hull is expressed in metres.

3.3.2
length waterline
L_{WL}
waterline length measured according to ISO 8666 when the boat is upright in calm water, in the appropriate loading condition and at design trim

NOTE 1 For multihull boats, L_{WL} relates to that of the longest individual hull.

NOTE 2 Length waterline is expressed in metres.

3.3.3
beam of hull
B_H
maximum beam of the hull using the method of ISO 8666; for catamaran and trimaran boats, maximum beam across the outer hulls

NOTE Beam of hull is expressed in metres.

3.3.4
beam waterline
B_{WL}
greatest beam measured according to ISO 8666 at the waterline in calm water, which for multihull boats is the sum of the maximum waterline beams of all hulls, the boat being upright, in the appropriate loading condition and at design trim

NOTE Beam waterline is expressed in metres.

3.3.5
freeboard amidships
F_{M}
distance of the sheerline or deck above the waterline at $L_{\mathrm{WL}}/2$ measured according to ISO 8666, the boat being upright, in the appropriate loading condition and at design trim

NOTE 1 Freeboard amidships is expressed in metres.

NOTE 2 Where no loading condition is specified, maximum load condition should be assumed.

3.3.6
draught of 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 in the appropriate loading condition and at design trim

NOTE Draught of canoe body excludes appendages such as rudders or skegs, and is expressed in metres.

3.3.7
windage area
A_{LV}
projected profile area of hull, superstructures, deckhouses, outboard motors and spars above the waterline at the appropriate loading condition, the boat being upright

NOTE 1 Canopies and screens that can be erected when under way in bad weather are included, e.g. cockpit dodgers, pram hoods.

NOTE 2 Windage area is expressed in square metres.

3.3.8
reference sail area
A_{S}
actual profile area of sails set abaft a mast, plus the maximum profile areas of all masts, plus reference triangle area(s) forward of each mast as defined in ISO 8666

NOTE Sail area is expressed in square metres.

3.3.9
angle of vanishing stability
ϕ_{V}
angle of heel nearest the upright (other than upright) in the appropriate loading condition at which the transverse stability righting moment is zero

NOTE 1 This is determined assuming that there is no offset load, and that all potential downflooding openings are considered to be watertight.

NOTE 2 Where a boat has recesses which are not quick-draining, ϕ_{V} is to be taken as the downflooding angle to these recesses, unless the loss of buoyancy due to such recesses is fully accounted for in determining ϕ_{V}.

NOTE 3 Angle of vanishing stability is expressed in degrees.

3.4 Condition, mass and volume

3.4.1
empty craft condition
empty boat including fittings and equipment as listed below but excluding all optional equipment and fittings not included in the manufacturer's basic outfit:

a) structure: comprising all the structural parts, including any fixed ballast keel and/or drop keel/centreboard/daggerboard(s) and rudder(s);

b) ballast: any fixed ballast installed;

c) internal structure and accommodation: bulkheads and partitions, insulation, lining, built-in furniture, flotation material, windows, hatches and doors, permanently installed mattresses and upholstery materials;

d) permanently installed engine(s) and fuel system: comprising inboard engine(s), including all supplies and controls as needed for their operation, permanently installed fuel systems, including tanks;

e) fluids in permanently installed systems: residual working fluids as needed for their operation (see examples below), but excluding contents of fluid ballast systems and tanks, and main storage tanks which are included in maximum load

EXAMPLES Fluids in hot or cold water, fuel, lubricating or hydraulic oil systems.

f) internal equipment, including:

— all items of equipment permanently attached to the craft, e.g. tanks, toilet system(s), water transfer equipment;

— bilge pumping system(s), cooking and heating devices, cooling equipment, ventilation system(s);

— electrical installation and equipment, including permanently installed batteries mounted in the position intended by the builder;

— fixed navigational and electronic equipment;

— fixed fire fighting equipment, where fitted;

g) external equipment, including:

— all permanently attached standard or specified deck fittings, e.g. guardrails, pulpits and pushpits, bowsprits and their attachments, bathing platforms, boarding ladders, steering equipment, winches, sprayhood(s);

— awning(s), cockpit tables, gratings, signal mast(s), where fitted;

— mast(s), boom(s), standing and running rigging, in the stowed position ready for use; all standing and running rigging in place

NOTE The mass in the empty craft condition is denoted by m_{EC} and is expressed in kilograms.

3.4.2
light craft condition
empty craft condition plus standard equipment (3.5.12) plus removable ballast (whether solid or liquid) when supplied and/or intended by the manufacturer to be carried when the boat is afloat, with elements positioned as follows:

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 is(are) mounted in the working position(s);

b) where batteries are fitted, they are mounted in the position intended by the builder, and if there is no specific stowage provided for batteries, the mass of one battery for each engine over 7 kW is allowed for, and located within 1,0 m of the engine location;

c) all upwind sails supplied or recommended 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

NOTE 1 For the minimum mass of outboard engines and batteries, refer to Tables F.1 and F.2.

NOTE 2 The mass in the light craft condition is denoted by m_{LC} and is expressed in kilograms.

3.4.3
minimum operating condition
boat in the light craft condition with the following additions:

a) mass to represent the crew, positioned on the centreline near the main control position of:

— 75 kg where $L_{\mathrm{H}} \leq 8$ m,

— 150 kg where 8 m $< L_{\mathrm{H}} \leq 16$ m,

— 225 kg where 16 m $< L_{\mathrm{H}} <$ 24 m;

b) non-edible stores and equipment normally carried on the boat and not included in the manufacturer's list of standard equipment

EXAMPLES Loose internal equipment and tools, spare parts, dishes, kitchenware and cutlery, additional anchors, dinghy and outboard if carried aboard.

NOTE 1 Liquids in main storage tanks (e.g. fuel, drinking water, black and grey water, live wells, bait tanks, etc.) are excluded.

NOTE 2 Water ballast in tanks which are symmetrical about the centreline and which are intended by the builder to be used for variable asymmetric ballasting while under way is excluded;

NOTE 3 The mass in the minimum operating condition is denoted by m_{MO} and is expressed in kilograms

3.4.4
maximum load
load which the boat is designed to carry in addition to the light craft condition, comprising:

— the crew limit at 75kg each;

— the personal effects of the crew;

— stores and cargo (if any), dry provisions, consumable liquids;

— contents of all permanently installed storage tanks filled to 95 % of their maximum capacity, including fuel, drinking water, black water, grey water, lubricating and hydraulic oil, bait tanks and/or live wells; plus ballast water at 100 % capacity;

— consumable liquids in portable tanks (drinking water, fuel) filled to 95 % of the maximum capacity;

— dinghy or other small craft intended to be carried aboard, and any outboard motor associated with them;

— liferaft(s) if carried in excess of the minimum required in essential safety equipment;

— non-edible stores and equipment normally carried on the boat and not included in the manufacturer's list of standard equipment, e.g. loose internal equipment and tools, spare parts, additional anchors, dinghy and outboard if carried aboard;

— an allowance for the maximum mass of optional equipment and fittings not included in the manufacturer's basic outfit

NOTE 1 Liferafts are not included in essential safety equipment for design categories C and D.

NOTE 2 As a guide, not less than 20 kg per person should be allowed for personal effects on habitable boats.

NOTE 3 As a guide, the mass of yachting liferafts varies from approximately 12 + 2CL (kg) to double this, according to specification.

NOTE 4 The mass of maximum load is denoted by m_L and is expressed in kilograms.

3.4.5
maximum load condition
boat in the light craft condition with the maximum load added so as to produce the design trim

NOTE The mass in the maximum load condition is denoted by m_{LDC} and is expressed in kilograms.

3.4.6
loaded arrival condition
boat in the maximum load condition minus 85 % of the maximum capacity of fixed or portable storage tanks for fuel, oils and drinking water, and minus 90 % of edible stores, but including the worst combination of optional fittings or equipment with respect to stability

NOTE The mass in the loaded arrival condition is denoted by m_{LA} and is expressed in kilograms.

3.4.7
displacement volume
V_D
volume of displacement of the boat that corresponds to the appropriate loading condition, taking the density of water as 1 025 kg/m^3

NOTE Displacement volume is expressed in cubic metres.

3.5 Other terms and definitions

3.5.1
calculation wind speed
v_W
wind speed to be used for calculations

NOTE Calculation wind speed is expressed in metres per second.

3.5.2
crew
collective description of all persons onboard a boat

3.5.3
crew limit
CL
maximum number of persons (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, with crew, fluids, stores and equipment in the positions designated by the designer or builder

NOTE Crew are assumed to be in positions designated by the builder. In the absence of builder's instructions, crew and gear are assumed to be positioned in a manner most likely to provide a favourable test result, provided that such positions are consistent with the proper operation of the boat and that crew are assumed to be either standing at designated positions fitted with handholds, or seated.

3.5.5
essential safety equipment
loose equipment considered essential to the safe operation of the boat, which may include distress flares and rockets, lifebuoy with light and battery, first aid box, lifejackets, safety harnesses and lines, portable fire fighting equipment, flashlight, binoculars, radio (e.g. VHF), ball and cone visual signals, charts, navigational publications and, for design categories A and B, liferaft(s) sufficient for the crew limit in the corresponding design category

NOTE 1 Quantities carried may vary according to the size of boat, design category and crew limit.

NOTE 2 As a guide, the mass allowed for essential safety equipment but excluding any liferaft(s) should not be less than $3L_H$ (kg).

NOTE 3 The mass of yachting liferafts varies from approximately 12 + 2CL (kg) to double this, according to specification.

NOTE 4 Liferafts are not considered to be essential safety equipment in design categories C and D.

3.5.6
flotation element
element which provides buoyancy to the boat and thus influences its flotation characteristics

3.5.6.1
air tank
tank made of hull construction material, and integral with hull or deck structure

3.5.6.2
air container
container made of stiff material, and not integral with the hull or deck structure

3.5.6.3
low density material
material with a specific gravity of less than 1,0 primarily incorporated into the boat to enhance the buoyancy when swamped

3.5.6.4
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

3.5.6.5
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 regarded as flotation elements.

3.5.7
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, enables all the intact stability parameters to be calculated.

NOTE 2 A full description of how to conduct an inclining experiment is given in standard naval architecture textbooks, e.g. references [2] and [3] in the bibliography.

3.5.8
loaded waterline
waterline of the boat when upright in the maximum load condition

3.5.9
recess retention level
level of water in recesses, other than those described by 6.5.1 a) to d), at which the unobstructed drainage area, when the boat is in the loaded arrival condition and at design trim, exceeds 5% of the volume of the recess to the lowest point of the peripheral coaming, assuming any gates or doors are sealed

NOTE The area of drainage openings is expressed in square metres and the volume is expressed in cubic metres.

3.5.10
righting lever
GZ
at a specific heel or trim angle in calm water, the distance in both the horizontal and transverse planes between the centre of buoyancy and the centre of gravity

NOTE Righting lever is equal to the righting moment divided by the product of mass, in kilograms, and acceleration due to gravity (9,806 m/s^2) and is expressed in metres.

3.5.11
righting moment
RM
at a specific heel or trim angle in calm water, the restoring moment generated by the transverse offset of the centre of buoyancy of the submerged part of the hull from the centre of gravity of the boat

NOTE 1 The righting moment varies with heel angle and is usually plotted graphically against heel angle. Righting moments are most accurately derived by computer from 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 hull form, centre of gravity position, boat mass and trim attitude.

NOTE 2 Righting moment is expressed in newton metres or kilonewton metres.

3.5.12
standard equipment
devices including outboard motors (excluding those for tenders), loose furniture and furnishings such as tables, chairs, non-permanently installed mattresses, curtains, etc., portable bilge pumping equipment, anchors, chain, warps, sails, loose external equipment such as fenders, boathook and boarding ladder, oars (if appropriate), and essential safety equipment

NOTE 1 Where outboard engine(s) are fitted, the heaviest engine(s) recommended for the boat by the manufacturer is(are) included, the mass allowed for outboard engines and their batteries (if not permanently installed) not being less than that given in columns 1 and 3 of Tables F.1 and F.2.

NOTE 2 As a guide, the mass allowed for anchors, anchor chain, warps and fenders should not be less than about $0{,}25L_H^{2,2}$ (kg). In some cases up to double this mass may be appropriate.

3.5.13
watertightness degree
degree of watertightness as specified in ISO 11812 and ISO 12216

NOTE The degree of watertightness is summarized 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.

3.5.14
under way
not at anchor, or made fast to the shore, or aground

4 Symbols

For the purposes this part of ISO 12217, the symbols and associated units in Table 1 apply.

Table 1 — Symbols

Symbol	Unit	Meaning
ϕ	degree (°)	Angle of heel
ϕ_D	degree (°)	Downflooding angle of any downflooding opening, see 3.2.2
ϕ_{DA}	degree (°)	Downflooding angle at which a certain area of openings are submerged, see 3.2.2
ϕ_{GZmax}	degree (°)	Angle of heel at which maximum righting moment or lever occurs
ϕ_O	degree (°)	Angle of heel measured during offset-load test, see 6.2 and Annex B
$\phi_{O(R)}$	degree (°)	Maximum permitted heel angle during offset-load test, see 6.2.3
ϕ_R	degree (°)	Assumed roll angle in a seaway, see 6.3.2
ϕ_V	degree (°)	Angle of vanishing stability, see 3.3.9
ϕ_W	degree (°)	Angle of heel due to calculation wind speed, see 6.4
A_{LV}	m^2	Windage area of hull in profile at the appropriate loading condition, see 3.3.7
A'_{LV}	m^2	Windage area of hull in profile but not less than $0{,}55 L_H B_H$, see 6.3.2
A_S	m^2	Reference sail area according to 3.3.8
B_H	m	Beam of hull according to 3.3.3 and ISO 8666
B_{WL}	m	Beam waterline according to 3.3.4, which for multihull boats is the sum of the maximum waterline beams of all hulls
CL		Crew limit = maximum number of persons on board, see 3.5.3
d		Density coefficient for submerged test weights, see F.3
F_M	m	Freeboard amidships at the appropriate loading condition, see 3.3.5
GM_T	m	Transverse metacentric height
GZ	m	Righting lever = righting moment (N·m)/[mass (kg) × 9,806(m/s^2)], see 3.5.10
h	m	vertical distance between geometric centres of A_{LV} and underwater profile area, see 6.3.2
h_D	m	Actual downflooding height, see 3.2.3 and 6.1.2
$h_{D(R)}$	m	Required downflooding height, see 6.1.2
LCG	m	Longitudinal position of the centre of gravity from a chosen datum
L_H	m	Length of hull measured according to 3.3.1
L_{WL}	m	Length of waterline in the appropriate loading condition according to 3.3.2
m	kg	Mass of boat, used where more than one loading condition is considered
m_{EC}	kg	Mass of the boat in the empty craft condition, see 3.4.1
m_L	kg	Mass of the maximum load, see 3.4.4
m_{LA}	kg	Mass of the boat in the loaded arrival condition, see 3.4.6
m_{LC}	kg	Mass of the boat in the light craft condition, see 3.4.2
m_{LDC}	kg	Mass of the boat in the maximum load condition, see 3.4.5
m_{MO}	kg	Mass of the boat in the minimum operating condition, see 3.4.3
M_W	N·m	Heeling moment due to wind, see 6.3.2
RM	N·m	Righting moment, see 3.5.11
T_C	m	Draught of canoe body at the appropriate loading condition according to 3.3.6
V_D	m^3	Displacement volume, see 3.4.7
V_R	m^3	Volume of a non-quick-draining recess, see Annex A
v_W	m/s	Calculation wind speed, see 3.5.1
VCG	m	Vertical position of the centre of gravity from a chosen datum
x_D	m	Longitudinal distance of downflooding opening from nearest extremity of L_H
x'_D	m	Longitudinal distance of downflooding opening from forward end of L_H
y_D	m	Transverse distance of downflooding opening from periphery of boat

Table 1 *(continued)*

Symbol	Unit	Meaning
y'_D	m	Transverse distance of downflooding opening off centreline
z_D	m	Height above waterline of downflooding opening

5 Procedure

5.1 Maximum load

Decide on the crew limit and the maximum load that the boat is intended to carry in accordance with the definitions. The crew limit shall not exceed that determined by the seating or standing space requirements of ISO 14946.

IMPORTANT — Ensure that the maximum load is not underestimated.

NOTE If a boat is assessed with different amounts of maximum load, different design categories may be assigned according to the load.

5.2 Sailing or non-sailing

Confirm that the boat is defined as non-sailing. Non-sailing boats are those where

$$A_S < 0{,}07 \times (m_{LDC})^{2/3} \quad (1)$$

where

A_S is the reference sail area according to 3.3.8 (expressed in square metres) and ISO 8666, and

m_{LDC} is the mass of the boat in the maximum load condition as defined in 3.4.5.

Other boats are sailing boats and shall be assessed using ISO 12217-2.

5.3 Tests and calculations to be applied

5.3.1 Non-sailing boats, whether monohull or multihull, 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 suitable recesses. 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. See Annex I.

NOTE For any given test, the requirements may vary according to the chosen option, e.g. for downflooding height.

5.3.2 Where boats are fitted with a bow loading ramp then either the bow ramp must be watertight to degree 2 (see 3.5.13) or the boat must comply with this part of ISO 12217 when the bow ramp is open.

5.4 Variation in input parameters

Users of this part of ISO 12217 shall consider the effect on compliance of variations in the empty craft mass within the builder's manufacturing tolerances.

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 enclosed boat**[a]	**Fully enclosed boat**[a]	**Any boat**	**Any boat**	**Partially protected boat**[b]	**Any boat except fully enclosed boat**[c]
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[d]	6.1.2	6.1.2
Downflooding angle	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[e]	—	6.4[e]	6.4 [e]	6.4[e]
Recess size	6.5	6.5[f]	—	—	—	6.5.4
Habitable multihulls	6.6	6.6	6.6	6.6	6.6	6.6
Motor sailers	6.7	—	—	—	—	—
Flotation requirements	—	—	6.8	6.8	—	—
Flotation material	—	—	Annex G	Annex G	—	—
Detection and removal of water	6.9	6.9	6.9	6.9	6.9	6.9

a This term is defined in 3.1.6.

b This term is defined in 3.1.7.

c That is, any boat that is not “fully enclosed”, thus including boats without any decking.

d The downflooding height test is not required to be conducted on some boats – see 6.1.2.1.

e The application of 6.4 is only required for boats where, in the minimum operating condition, $A_{LV} \geq 0{,}5 L_{WL} B_H$.

f This requirement only applies to design category C.

6 Tests, calculations and requirements

6.1 Downflooding

NOTE These requirements are to ensure that a level of watertight integrity appropriate to the design category is maintained.

6.1.1 Downflooding openings

6.1.1.1 All closing appliances (as defined in ISO 12216) such as windows, portlights, hatches, deadlights and doors shall comply with ISO 12216, according to design category and appliance location area.

6.1.1.2 No hatches or opening type windows shall be fitted in the hull with the lowest part of the opening less than 0,2 m (design category A, B or C) or 0,1 m (design category D) above the loaded waterline, except for emergency escape hatches on design category C boats, where 0,1 m is allowable.

6.1.1.3 Seacocks complying with ISO 9093-1 and ISO 9093-2, respectively, together with means of preventing flow into the boat when the seacock is open shall be fitted to through-hull pipe fittings located with any part of the opening below the loaded waterline when the boat is upright apart from:

a) engine exhausts, or

b) drains forming an integral part of the hull and of equal strength and tightness extending from the outlet to above the fully loaded waterline by at least 0,12 m for design category A, 0,08 m for design category B, 0,06 m for design category C or 0,04 m for design category D.

NOTE 1 Means of preventing flow into the boat may comprise:

— a pipe or hose extending above the loaded waterline, or

— a pipe or hose leading to a downflooding point above the loaded waterline, or

— a non-return valve, or

— a pipe or hose connected to a system that cannot flood the interior of the boat, or

— for seacocks not connected internally, a permanent cap or means of securing the seacock in the closed position.

Instructions for the correct and safe operation of seacocks shall be included in the owner's manual.

NOTE 2 Special requirements for seacocks on bilge system discharges are given in ISO 15083.

6.1.1.4 Openings within the boat, such as outboard engine trunks or free-flooding fish bait tanks, shall be considered as possible downflooding openings.

6.1.1.5 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 not in Area I (as defined in ISO 12216) and are essential for cabin or engine ventilation requirements, but these shall at least comply with tightness degree 3.

6.1.1.6 The requirements given in 6.1.2 and 6.1.3 apply to all downflooding openings except:

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

b) drains from:

   — quick-draining recesses or

   — watertight recesses which, if filled, would not lead to downflooding or capsize when the boat is upright

and which:

   1) are freeing ports fitted with non-return flap closures which are watertight from the exterior to degree 3 of ISO 12216, or

   2) have a combined cross-sectional area smaller than three times the minimum area required to comply with ISO 11812 for quick-draining cockpits.

c) non-opening appliances which comply with ISO 12216;

d) opening appliances located in the topsides which comply with ISO 12216 which are:

   1) referenced in the owner's manual as watertight closure to be kept shut when under way, and

   2) clearly marked on the inboard side “KEEP SHUT WHEN UNDER WAY” in upper case letters not less than 4,8 mm high, and

   3) positioned so that the lowest part of the opening is above the loaded waterline by at least 50 % of the minimum downflooding height required by 6.1.2 or in the case of means of escape fitted to habitable multihulls considered to be vulnerable to inversion (see 6.6) positioned with the bottom of the clear opening not less than 0,2 m (design category A or B) or 0,1 m (design category C or D) above the loaded waterline when the boat is upright.

e) opening appliances which are fitted in a compartment of such restricted volume that, even if flooded, the boat satisfies all the requirements;

f) opening appliances located other than in the topsides which comply with ISO 12216 to tightness degree 2 and which are referenced in the owner's manual as being “KEEP SHUT WHEN UNDER WAY” and clearly marked as such on the appliance on the inboard side in upper case letters not less than 4,8 mm high;

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

h) discharge pipes fitted with non-return valves;

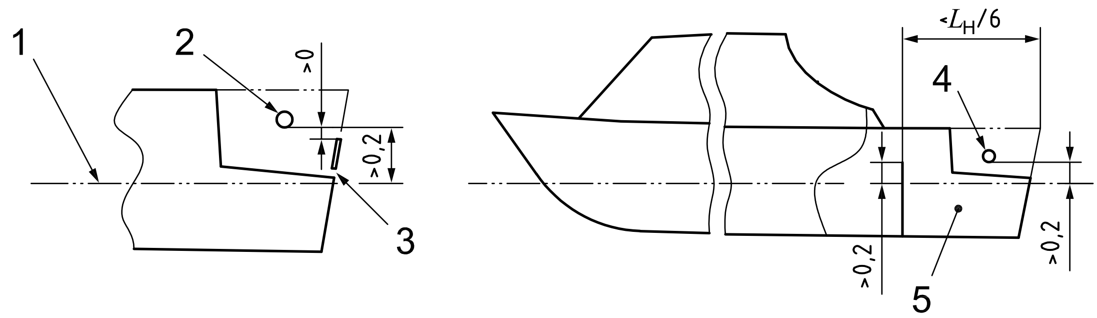
i) openings in the sides of outboard engine wells which are of:

1) watertightness degree 2 and having the lowest point of downflooding more than 0,1 m above the loaded waterline, or

2) 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 well drain holes are fitted, see Figure 2, or

3) watertightness degree 4 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 well drain holes are fitted, and that the part of the interior or non-quick-draining spaces into which water might 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, see Figure 2.

Dimensions in metres



Key

1 waterline
2 watertightness degree 3 or 4
3 drain
4 watertightness degree 4
5 non-quick-draining space

Figure 2 — Openings in outboard engine wells

6.1.2 Downflooding height

6.1.2.1 Test

This test is to demonstrate sufficient margins of freeboard for the boat in the maximum load condition before water is shipped aboard.

The downflooding height test is not required to be conducted on the following design category C and D boats:

— those which, when tested in accordance with F.4, have been shown to support, in addition to the mass required by F.2 and Table F.5, in the same location, an additional equivalent dry mass (kg) of (75CL + 10 % of dry mass of stores and equipment included in the maximum load), or

— those which do 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, or 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 a number of people equal 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 load, with the people positioned 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 those excluded in 6.1.1.6. Where a downflooding opening is fully protected by a higher coaming around the recess from which it leads, the downflooding height shall be measured to the lowest point of water ingress of that coaming – see Figure C.1. Where an opening in the hull is permanently attached to a watertight pipe or trunk rising to a higher level within the boat, the downflooding height is taken to the critical height within that pipe or trunk – see Figures C.1 and D.3.

Downflooding height to downflooding points within quick-draining or watertight recesses shall be measured as though the following openings are closed:

— freeing ports fitted with non-return flap closures 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.

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

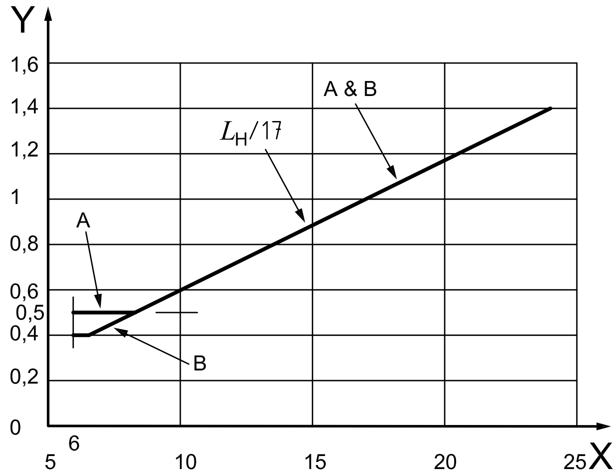
   1) the method of Annex A, which generally gives the lowest requirement, or

   2) Figures 3 and 4, which are based only on boat length.

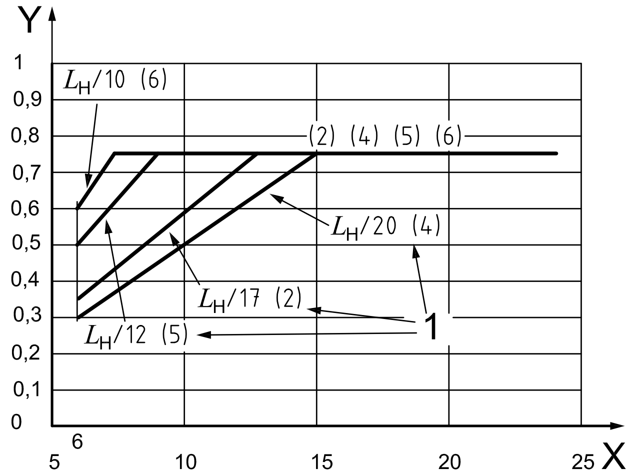
b) For boats assessed using option 3, 4 or 6 (see Table 2), the required downflooding height within $L_H/3$ of the bow shall be increased as shown in Figure 5.

c) Boats assessed using option 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 Figure 3 or 4 shall be permitted downflooding openings having a combined clear area, in square millimetres (mm^2), of not more than $50L_H^2$ within the aft quarter of L_H, provided that the downflooding height to these openings is not less than 75 % of that required by these figures.



a) Design categories A and B



b) Design category C

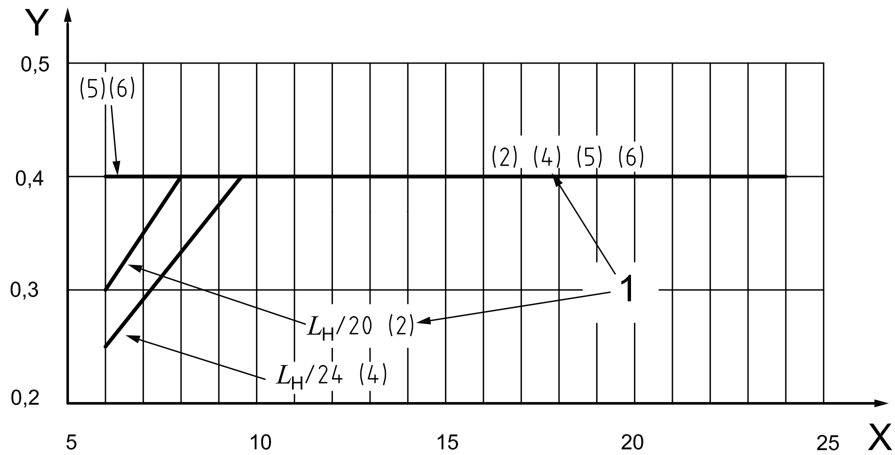
Key

X length of hull (m)

Y required downflooding height (m)

1 option numbers (see Table 2)

Figure 3 — Required downflooding height — design categories A, B and C



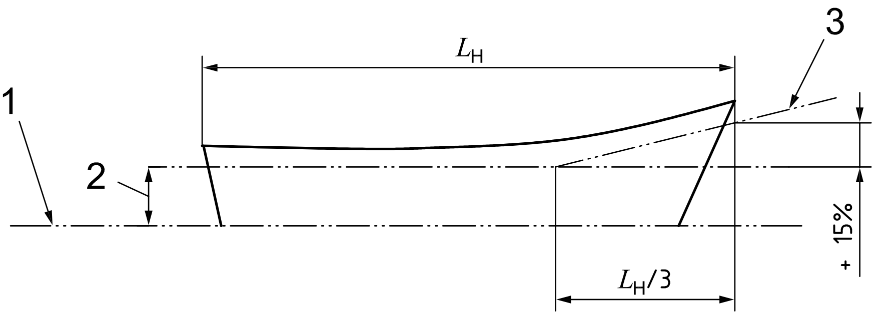
Key

X length of hull (m)

Y required downflooding height (m)

1 option numbers (see Table 2)

Figure 4 — Required downflooding height — design category D



Key

1 waterline

2 basic downflooding height requirement

3 increased requirement forward

Figure 5 — Increase in required downflooding height — options 3, 4 and 6

6.1.3 Downflooding angle

This requirement is to show that there is sufficient margin of heel angle before significant quantities of water can enter the boat.

Boats shall be assessed in both the minimum operating and loaded arrival conditions.

The angle of heel ϕ_{DA} at which downflooding opening(s) (except those listed in 6.1.1.6) which are not marked "KEEP SHUT WHEN UNDER WAY" and having a total combined area, expressed in square centimetres (cm^2), greater than the number represented by ($1{,}2 L_H B_H F_M$) first become immersed shall be greater than the requirements given in Table 3 as a function of the measured offset-load heel angle (ϕ_O), see 6.2.

Table 3 — Downflooding angle requirements

Design category	Minimum downflooding angle degrees Options 1 and 3 [a], use whichever is the greater	
A	$\phi_O + 25$	30
B	$\phi_O + 15$	25

[a] See Table 2.

Where a downflooding opening is protected by a higher coaming around the recess from which it opens, the downflooding angle shall be determined to the lowest point of that coaming, see Figure C.1.

The downflooding angle (ϕ_{DA}) can be determined using either of the methods in Annex C.

6.2 Offset-load test

6.2.1 Objective

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

The test considers the hazards of downflooding, excessive heel angle and sudden loss of stability caused by the heeling moment exceeding the maximum righting moment. It also considers the possible variations in vertical positioning of the crew on boats with more than one deck or cockpit level.

6.2.2 Test

Conduct the offset-load test in accordance with Annex B using either the simplified method or the full method.

NOTE The simplified method incorporates greater safety margins and is most suitable for boats with generous static stability in relation to the crew limit, e.g. those with a crew limit of less than one per metre length.

The full method can be applied, using either the physical test or the calculation method. The simplified method can only be applied by calculation.

6.2.3 Requirements

a) Except for design category D boats that are not fully-enclosed, during the test the heel angle ϕ_O shall be not greater than $\phi_{O(R)} = 11{,}5 + \frac{(24 - L_H)^3}{520}$ (see Table 4).

Table 4 — Maximum permitted heel angle for offset-load test for different lengths of hull

L_H (m)	6,0	7,0	8,0	9,0	10,0	12,0	15,0	18,0	21,0	24,0
$\phi_{O(R)}$ (°)	22,7	20,9	19,4	18,0	16,8	14,8	12,9	11,9	11,6	11,5

b) During the test, the freeboard margin to downflooding shall not be less than that given in Table 5.

Table 5 — Required minimum heeled freeboard margin during offset-load test

Dimensions in metres

Design category	A	B	C	D
Options 1 or 3 in Table 2	not applicable	not applicable	not applicable	not applicable
Options 2 or 4 in Table 2	not applicable	not applicable	0,014 L_H but not less than 0,1 m	0,010
Options 5 or 6 in Table 2	not applicable	not applicable	$0{,}110\sqrt{L_H}$	$0{,}070\sqrt{L_H}$

6.3 Resistance to waves and wind

6.3.1 General

This requirement is applicable only to boats of design categories A and B, which shall be assessed using 6.3.2 and 6.3.3, in both the minimum operating condition and the loaded arrival condition.

In the minimum operating condition, the crew shall be assumed to be located at the highest control position that can accommodate the number of persons corresponding to the minimum operating condition.

In the loaded arrival condition, the centre of gravity of the crew shall be assumed to be in positions typically used by the crew when the boat is under way (e.g. within the cabin, cockpit, deckhouse or wheelhouse) such positions being designated by the builder.

In both cases the VCG of the crew shall be 0,1 m above the surface on which they sit or stand, whichever is higher.

When assessing this criterion, righting moments shall take account of free-surface effects as described in E.2.4.

6.3.2 Rolling in beam waves and wind

The curve of righting moments of the boat shall be established up to the downflooding angle (determined according to 6.1.3) or the angle of vanishing stability or 50°, whichever is the least, using Annex E.

The heeling moment due to wind, M_W, expressed in newton metres, is assumed to be constant at all angles of heel and shall be calculated using either Formula 2 or Formula 3 below:

$$M_{W1} = 0{,}53\, A'_{LV}\, h\, v_W^2 \qquad (2)$$

or

$$M_{W2} = 0{,}30\, A'_{LV}\, (A'_{LV} / L_{WL} + T_M)\, v_W^2 \qquad (3)$$

where

h is the vertical distance between the geometric centres of A_{LV} and underwater profile area;

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

A'_{LV} is the windage area as defined in 3.3.7, but not less than $0{,}55 L_H B_H$;

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

NOTE Formula 2 usually gives a more advantageous result.

Alternatively, the heeling characteristics due to wind can be assessed from wind tunnel tests.

The assumed roll angle ϕ_R shall be calculated as follows:

$$\phi_R = 25 + 20/V_D \text{ for design category A, and } 20 + 20/V_D \text{ for design category B.} \qquad (4)$$

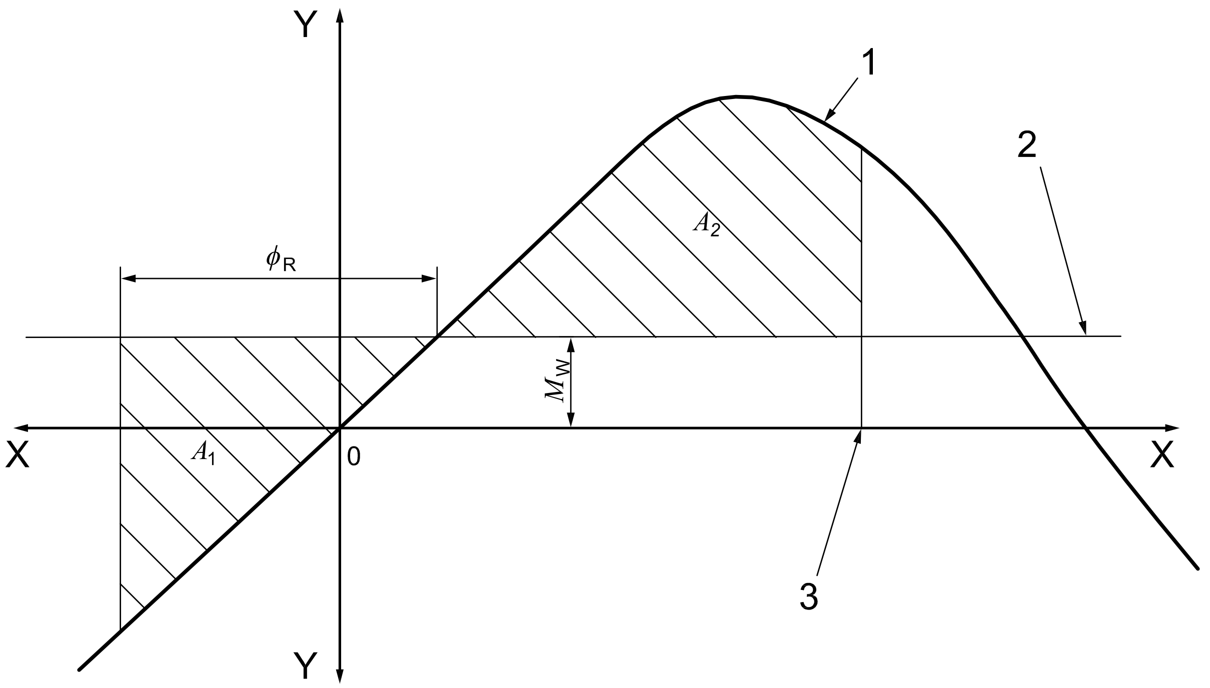
The righting moment curve and the wind heeling moment shall be plotted on the same graph as shown in Figure 6. Area A_2 shall be greater than area A_1, where A_1 and A_2 are the areas indicated in Figure 6.

6.3.3 Resistance to waves

In addition to the requirements of 6.3.2, the curve of righting levers at angles of heel up to ϕ_{DA}, ϕ_V or 50°, whichever is the least, shall comply with the following.

a) Where the maximum righting moment occurs at a heel angle of 30° or more, the righting moment at 30° heel shall be not less than 25 kN·m for design category A, and 7 kN·m for design category B. In addition, the righting lever at 30° shall be not less than 0,2 m.

b) Where the maximum righting moment occurs at a heel angle of less than 30°, the maximum righting moment shall be not less than $(750/\phi_{GZmax})$ kN·m for design category A, and $(210/\phi_{GZmax})$ kN·m for design category B. In addition, the maximum righting lever shall not be less than $(6/\phi_{GZmax})$ m, where ϕ_{GZmax} is the heel angle, in degrees, at which the maximum righting lever occurs, considering only that part of the curve for heel angles less than the downflooding angle.



Key

X heel angle (degrees)

Y righting or heeling moment (kN·m)

1 righting moment (kN·m)

2 heeling moment due to wind (kN·m)

3 ϕ_{A2} = least of ϕ_{DA} or 50° or second wind heel equilibrium angle

Figure 6 — Roll resistance to waves and wind

6.4 Heel due to wind action

6.4.1 General

This requirement is only applicable to boats where, in the minimum operating condition, $A_{LV} \geq 0{,}55 L_{WL} B_H$.

Boats of design categories C and D shall be assessed in both the loaded arrival condition and the minimum operating condition.

NOTE This requirement does not apply to boats of design categories A and B.

When assessing this criterion, righting moments shall take account of free-surface effects as described in E.2.4.

6.4.2 Calculation

The wind heeling moment (M_W) shall be calculated using either Formula 2 or Formula 3 in 6.3.2, and:

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

— substituting A_{LV} in place of A'_{LV}, where A_{LV} is the windage area as defined in 3.3.7

NOTE Formula 2 usually gives a more advantageous result.

6.4.3 Requirement

The heel angle due to the wind heeling moment, ϕ_W, shall be determined either:

a) by comparing the wind heeling moment with the curve of righting moments, or

b) by physical test, applying a static heeling moment equal to the wind heeling moment and measuring the resulting heel angle.

The angle ϕ_W shall be less than 70 % of the maximum allowable heel angle in the offset-load test, derived from 6.2.3 and Table 4, and 70 % of the downflooding angle, ϕ_D, determined using either of the methods of Annex C.

6.5 Recess size

6.5.1 Application

This requirement is applicable only to boats of design categories A and B, or those fully enclosed boats of design category C for which the minimum freeboard to the recess coaming does not exceed the required downflooding height of option 6. The boat shall be assessed in the loaded arrival condition. The requirements of either 6.5.2 or 6.5.3 shall be applied to recesses except those

a) fitted to boats with an angle of vanishing stability greater than 90°, or

b) where the depth of the recess is less than 3 % of the maximum breadth of the recess over at least 35 % of the periphery, or

EXAMPLE Toe rails, low bulwarks.

c) formed by a bulwark with at least 5 % of its area providing overboard drainage positioned within the lowest 25 % of its height, and where the height of the bulwark is less than 12,5 % of the maximum breadth of the recess, or

d) where it can be shown that the unobstructed drainage area from the recess on each side of the boat centreline exceeds K x (the volume of the recess to the recess retention level defined in 3.5.9), where K is:

— 0,09 where the drainage openings are within the lowest 25 % of the recess depth;

— 0,16 where the drainage openings are within the lowest 50 % of the recess depth;

— 0,30 where the drainage openings are the full depth of the recess.

To qualify under this paragraph:

1) the lower edge of these drainage openings shall be not more than 10 mm above recess sole height for at least 70 % of the width of each opening, and

2) where this drainage area is provided by an open or partially open transom, openings shall extend to the outboard sides of the recess sole on both sides.

NOTE The area of drainage openings is expressed in square metres and the volume is expressed in cubic metres.

Recesses completely or partially located within any third of the length must be considered to be swamped simultaneously.

Linked recesses shall be treated as being separate if more than 80 % of the volume of each one cannot drain into an adjacent linked recess. Where two recesses are linked by side decks, the total open cross-sectional area linking the forward and aft recesses must be greater than (open area at transom) × (volume of forward recess) / (volume of all linked recesses).

6.5.2 Simplified methods

6.5.2.1 The percentage loss in initial metacentric height (GM_T) due to free-surface effect when the recess is filled to the retention level defined in 3.5.9 and the boat is in the loaded arrival condition shall be not more than:

— 250 F_R / L_H for boats of design category A;

— 550 F_R / L_H for boats of design category B;

— 1 200 F_R / L_H for boats of design category C;

where

F_R is the average freeboard to the waterline of the periphery of the recess

$$= (F_A + 2F_S + F_F) / 4 \tag{5}$$

where

F_A is the average of highest and lowest freeboard to the waterline across aft end of recess;

F_S is the average of highest and lowest freeboard to the waterline along the sides of recess;

F_F is the average of highest and lowest freeboard to the waterline across forward end of recess.

Compliance with this requirement can be demonstrated by any of the methods given in 6.5.2.2, 6.5.2.3, or 6.5.2.4 for monohulls, or 6.5.2.2 or 6.5.2.3 for multihulls.

Alternatively, the direct calculation method of 6.5.3 can be used.

NOTE Each method given below is increasingly approximate, but in some cases 6.5.2.3 or 6.5.2.4 may be slightly more advantageous than 6.5.2.2.

6.5.2.2 The percentage loss in initial metacentric height (GM_T) due to free-surface effect can be calculated from:

$$\% \text{ loss } GM_T = \frac{102\,500 \times SMA_{RECESS}}{m_{LA} \times GM_T} \tag{6}$$

where

SMA_{RECESS} is the second moment of area of free-surface of recess at retention height as defined in 3.5.9, about the longitudinal axis through the centre of area, expressed in m^4

Where multiple recesses have to be considered swamped simultaneously, SMA_{RECESS} must include all such recesses.

6.5.2.3 The percentage loss in initial metacentric height (GM_T) due to free-surface effect can be estimated from

$$\% \text{ loss } GM_T = \left(\frac{220 \times SMA_{RECESS}}{SMA_{WP}} \right) \tag{7}$$

where

SMA_{RECESS} is the second moment of area of free-surface of recess at retention height as defined in 3.5.9;

SMA_{WP} is the second moment of area of waterplane of boat at m_{LA}.

Both second moments of area are about the longitudinal axis through the respective centre of area, expressed in m^4.

Where multiple recesses have to be considered swamped simultaneously, SMA_{RECESS} must include all such recesses.

6.5.2.4 The percentage loss in initial metacentric height (GM_T) due to free-surface effect can alternatively be estimated more approximately, and therefore more conservatively, from:

$$\% \text{ loss GM}_T = 240\left(\frac{l \times b^3}{L_H \times B_H{}^3}\right)^{0,7} \tag{8}$$

where

l is the maximum length of recess at the retention level as defined in 3.5.9;

b is the maximum breadth of recess at the retention level as defined in 3.5.9.

Where multiple recesses have to be considered swamped simultaneously, l shall be the sum of the length of individual recesses and b shall be the maximum value of any recesses considered swamped at the same time.

NOTE This method is not applicable to multihull boats.

6.5.3 Direct calculation method

a) Calculate the righting moment curve (N·m) for the boat in the loaded arrival condition in calm water using computer modelling which correctly represents (in calm water) the heel, heave and trim of the boat, and with water in the recess allowed to flow in or out over gunwales or coamings according to the attitude of the boat in calm water, assuming that no flow through drains occurs. When the boat is upright, the recess shall be assumed to be filled to the following percentage of the capacity at the recess retention level defined in 3.5.9:

$$(60 - 240\ F/L_H)\ \% \tag{9}$$

where

F is the minimum freeboard to the waterline of the coaming of the recess in question.

b) Calculate the wind heeling moment (N·m) according to 6.3.2 or 6.4 using the appropriate value for the wind speed according to design category.

c) Calculate the maximum crew heeling moment used in the offset-load test (N·m) (using 85 kg per person) and varying as cosϕ over the required range of heel angles.

d) In the range from the steady equilibrium heel angle due to the greater of b) or c) to the least of the downflooding angle ϕ_{DA}, the angle of vanishing stability ϕ_V and 50°, the maximum residual righting moment (N·m) shall be at least:

— 2,0m_{LA} for design category A;

— 1,0m_{LA} for design category B;

— 0,5m_{LA} for design category C;

where

m_{LA} is the mass of the boat in the loaded arrival condition without any swamp water,

ϕ_{DA} is the angle of heel at which openings (except those excluded in 6.1.1.6), not marked "KEEP SHUT WHEN UNDER WAY" and having a total combined area, expressed in square centimetres (cm^2), greater than the number represented by (1,2$L_H B_H F_M$), first become immersed.

6.5.4 Design category C boats using option 6

Recesses fitted to design category C boats using option 6 having a volume to retention level (see 3.5.9) larger than ($L_H B_H F_M$)/40, entirely contained within L_H/2 of the bow shall either be quick-draining (overboard) or drain to the bilge in the same time or less.

6.6 Habitable multihull boats

6.6.1 Multihull boats which are habitable as defined in 3.1.8, if considered to be vulnerable to inversion when used in their design category according to 6.6.2 to 6.6.4, shall comply with:

a) the requirements for inverted buoyancy given in ISO 12217-2:2013, 7.12, and

b) the requirements for means of escape given in ISO 12217-2:2013, 7.13.

6.6.2 Boats of design category A or B that comply with 6.2 and 6.3 are not considered to be vulnerable to inversion.

6.6.3 Boats of design category C are considered to be vulnerable to inversion if:

$$h_C / B_H > 0{,}572 \text{ when } V_D^{1/3} > 2{,}6 \quad (10)$$

$$h_C / B_H > 0{,}22\, V_D^{1/3} \text{ when } V_D^{1/3} \le 2{,}6 \quad (11)$$

where

h_C is the height of the centroid of the above water profile area above the waterline in the minimum operating condition, expressed in metres;

V_D is the volume of displacement in the minimum operating condition, expressed in cubic metres.

6.6.4 Boats of design category D that comply with 6.2 and 6.4 are not considered to be vulnerable to inversion.

6.7 Motor sailers

6.7.1 General

This clause is applicable to boats defined as “non-sailing” in accordance with 3.1.2, but which are fitted with masts and sails.

6.7.2 Requirement

The wind heeling moment calculated as follows shall be less than 50 % of the maximum righting moment up to the downflooding angle, ϕ_{DA}, of the boat in the loaded arrival condition.

The heeling moment due to wind, M_W, expressed in newton metres, is assumed to be constant at all angles of heel and shall be calculated from:

$$M_W = 0{,}53\, A_{max}\, h\, v_W^2 \quad (12)$$

where

h is the vertical distance between the geometric centres of A_{MAX} and underwater profile area;

A_{max} is the sum of the windage area as defined in 3.3.7 plus the actual profile area, including overlaps, of the largest sail plan suitable for windward sailing in true winds of more than 10 kn to 12 kn (5,1 m/s to 6,2 m/s) and supplied or recommended by the builder as standard;

v_W = 18 m/s for design category A, and 14 m/s for design category B.

6.8 Flotation requirements

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

The downflooding height test is not required to be conducted on the following design category C and D boats:

— those which, when tested in accordance with F.4, have been shown to support, in addition to the mass required by F.2 and Table F.5, in the same location an additional equivalent dry mass (kg) of (75CL + 10 % of dry mass of stores and equipment included in the maximum total load), or

— those boats that do not take on water when heeled to 90° from the upright in the light craft condition.

6.9 Detection and removal of water

6.9.1 The internal arrangement of a boat shall facilitate the drainage of water, either

— to bilge suction point(s),

— to a location from which it can be bailed rapidly, or

— directly overboard.

6.9.2 Boats shall be provided with means of removing water from the bilges in accordance with ISO 15083. The bilge pumping capacity (l/min) must reflect the degree of decking and consequent risk of water entering the boat.

6.9.3 Design category C boats using options 5 or 6 shall be provided with means of detecting the presence of water in the bilge from the helm position, which shall comprise:

— direct visual inspection, or

— transparent inspection panels in interior mouldings, or

— bilge alarms, or

— indication of the operation of automatic bilge pumps, or

— other equivalent means.

NOTE Essential requirement 3.5 of EU Directive 94/25/EC requires that all craft shall be designed so as to minimize the risk of sinking, and that particular attention should be paid where appropriate to:

— cockpits and wells, which should be self-draining or have other means of keeping water out of the boat interior,

— ventilation fittings,

— removal of water by pumps or other means.

7 Application

7.1 Deciding the design category

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

7.2 Meaning of the design categories

NOTE Refer to Table 6.

7.2.1 A boat given design category A is considered to be designed to operate in winds of Beaufort force 10 or less and the associated wave heights, and to survive in more severe conditions. Such conditions might 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.

7.2.2 A boat given design category B is considered to be designed for waves of up to 4 m significant height and a wind of Beaufort force 8 or less. Such conditions might be encountered on offshore voyages of sufficient length or 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. Winds are assumed to gust to 21 m/s.

7.2.3 A boat given design category C is considered to be designed for waves of up to 2 m significant height and a typical steady wind force of Beaufort force 6 or less. Such conditions might 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.

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

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.

Table 6 — Summary of design category definitions

Parameter	Design category			
	A	B	C	D
Maximum wave height	approx. 7 m significant	4 m significant	2 m significant	0,3 m significant 0,5 m maximum
Typical Beaufort wind force	≤10	≤8	≤6	≤4
Calculation wind speed (m/s)	28	21	17	13

Annex A
(normative)

Full method for required downflooding height

The required downflooding height can be calculated according to the method set out below instead of using Figures 3 or 4. 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

Parameter	Design category					
	A	B	C	C	D	D
Options (see Table 2)	1	1, 3	2, 4, 5	6	2, 4, 5	6
$h_{D(R)}$ shall be not less than	0,5	0,4	0,3	0,5	0,2	0,4
$h_{D(R)}$ shall be not 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:

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

where

$H_1 = L_H/15$;

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

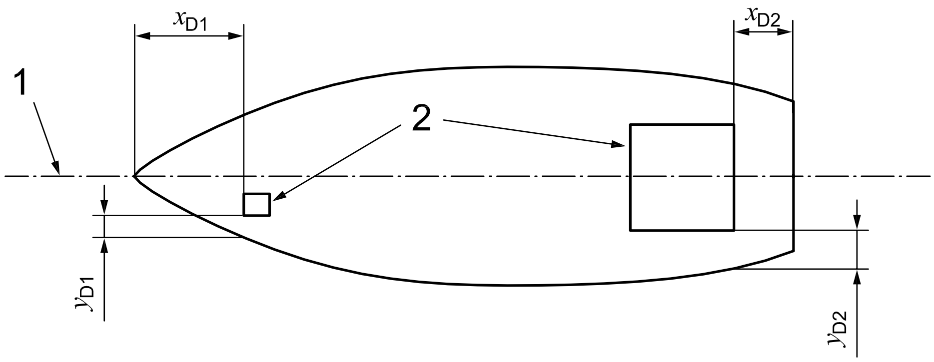
= 1,0 where the downflooding opening is in the periphery of the boat, e.g. for undecked, open boats, or openings in topsides:

$F_1 = (1 - x_D/L_H)$ or $(1 - y_D/B_H)$, whichever is greater, see Figure A.1. (A.2)

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;



Key

1 centreline

2 downflooding openings

Figure A.1 — Dimensions x_D and y_D

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

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

where

a is the total combined area of openings up to the top of any downflooding opening, expressed in square millimetres (mm²);

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

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

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

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):

$$F_4 = \left(\frac{10V_D}{L_H B^2}\right)^{1/3} \tag{A.6}$$

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 option 3 or 4 (see Table 2);

= 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 test can be conducted in any of the following ways:

a) physical test (full method only);

b) calculation with supporting tests, but including separate additional margins to allow for errors, see D.2 (full or simplified methods);

c) calculation using supporting information from an inclining experiment (full or simplified methods).

Details of the application of these alternatives are given in B.3 to B.5.

B.3 Methods

B.3.1 General

B.3.1.1 This test is to demonstrate sufficient stability against offset loading by the crew, for unswamped boats. If it is more convenient, people can be used instead of test weights provided that the mass of each person used equals or exceeds that of the relevant test weight. Calculation of stability using a mass for the boat established by measurement can be used instead of a practical test. Testing shall be conducted in conditions of smooth water and light winds.

B.3.1.2 Each boat shall be tested according to either the simplified method in B.3.2 or the full method in B.3.3. The full method can be applied using either the physical test or calculation method. The simplified method can only be applied by calculation.

NOTE The simplified method incorporates greater safety margins and is most suitable for boats with generous static stability in relation to the crew limit, e.g. those with a crew limit of less than one per metre length.

B.3.1.3 All boats shall be tested in the maximum load condition except that boats having any tank (fuel, fresh and black water, live wells, oils, etc.) that has a maximum transverse dimension greater than 0,35B_H shall be tested with all tanks as close as practicable to 50 % full, but never less than 25 % or more than 75 % full. Where application is by calculation, relevant tanks shall be assumed to be 50 % full and free-surface effect shall be represented either by a virtual increase in the VCG or by using computer software that models the movement of fluid in tanks.

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

B.3.1.4 In general, boats shall be tested when heeled to both port and starboard. However, where it is clearly evident that one direction of heel is the most critical, only heel angles in this direction need be tested.

EXAMPLE Initial list and/or lower downflooding openings on one side and/or crew area clearly asymmetrical.

B.3.1.5 During the tests, on boats with watertight or quick-draining cockpits, water may enter the cockpit through drains when the boat is heeled during the test, provided that this water drains overboard when all test weights on board are moved to the centreline. Where water enters the boat during the test, the heel angle and downflooding height measurements shall be recorded after the inflow of water has stopped.

B.3.1.6 During tests on design category C and D boats, the freeboard margin (remaining vertical height from the waterline) shall then be measured to the point at which water could first begin to enter the interior or bilge – see Annex D. When measuring the freeboard margin, downflooding openings through the topsides must also be considered. When making such measurements, one outboard engine well penetration fitted with a sealing boot can be regarded as watertight.

B.3.1.7 The “crew area” comprises the “working deck” as defined by the manufacturer in accordance with ISO 15085 plus the areas of all seats, bunks, sunbathing pads, cabin soles and internal decks. It shall include all areas designated to be used by the crew when the boat is stationary, but may exclude ledges less than 0,10 m in width and areas excluded by “no access” signs.

NOTE See ISO 15085:2003, 3.6, Note 3 for treatment of sloping surfaces.

If the manufacturer chooses to assess the stability by excluding some areas from the “crew area” or limiting the number of people on any given level:

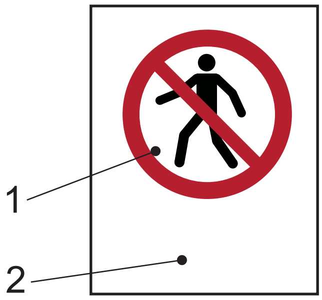
— such areas shall be listed in the owner’s manual, and

— such areas shall be physically marked at all clearly defined points of access with “no access” or “limited access” signs as illustrated in Figures B.1 and B.2, or

— a diagram shall be placed at each helm position identifying such areas and their access limitations – see Figure B.3, and in addition “no access” or “limited access” signs as illustrated in Figures B.1 and B.2 shall be placed at those points of access not visible from all alternative helm positions.

In open boats, the crew area comprises all the interior of the boat except for those areas excluded by “no access” signs. In dayboats it may be restricted to the cockpit provided that doing so still permits anchoring or mooring to be undertaken.

In Figure B.2, the number and the location should be adjusted as appropriate to the required restriction, e.g. coachroof, foredeck, flybridge.

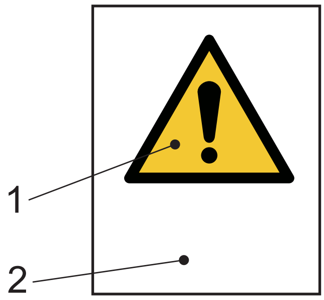


Key

1 sign P004 “No thoroughfare” from ISO 7010

2 supplementary text to read “No access”

Figure B.1 — No access sign

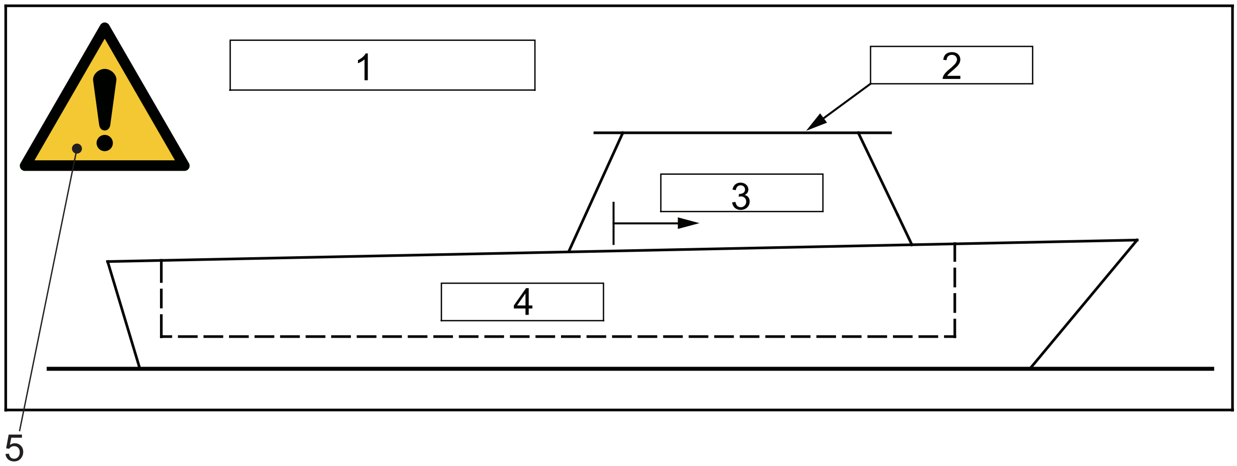


Key

1 sign W001 “General warning” from ISO 7010

2 supplementary text to read “Max N persons on (location)” where N is the relevant number and (location) is expressed for example as “flybridge” or “coachroof”

Figure B.2 — Limited access sign



Key

1 text stating maximum total number of persons

2 text stating any access limitations such as “Do not sit or stand”

3 text stating any access limitations such as “Max persons on deck = 2”

4 text stating any access limitations such as “No restriction”

5 sign W001 “General warning” from ISO 7010

Figure B.3 — Example of crew area and access limitation sign for control position

B.3.1.8 When such safety signs are fitted, they shall be placed where they are clearly visible, and shall be made of rigid plate or flexible labels affixed to the craft in such a way that they can only be removed by the use of tools. The size of the symbols and text in Figures B.1, B.2 and B.3 shall comply with Table B.1. Text shall be in black on a white background, using a plain sans serif typeface such as Arial Narrow. The language used shall be acceptable or as required in the country of intended use. The design of the signs shall comply with ISO 3864-1.

Table B.1 — Size of safety signs and supplementary text

Parameter	Expected viewing distance, D (m)				
	$D \le 0{,}6$	$0{,}6 < D \le 1{,}2$	$1{,}2 < D \le 1{,}8$	$1{,}8 < D \le 2{,}4$	$D > 2{,}4$
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".					

B.3.2 Simplified procedure for offset-load test

B.3.2.1 This method can only be applied by calculation.

B.3.2.2 Calculate the mass and centre of gravity of the boat for two loading conditions (LC1 and LC2) as follows:

— boat in maximum load condition except for the tanks, which are to be treated as described in B.3.1.3;

— VCG of the crew used shall represent the maximum number permitted (at 85 kg each) on the highest part of the crew area (as defined in B.3.1.7), for example: flybridge or coachroof top, located with their VCG 0,1 m above seats, and the maximum number of the crew permitted (at 85 kg each) on each successively lower part of the crew area (e.g. wheelhouse, main deck or cockpit), located with their VCG 0,1 m above the seats, until the total number of persons equals the intended crew limit. Where there are no seats, the VCG of crew shall be located 0,1 m above the surface on which they stand. Where no persons limit is stated by the builder, the maximum number of persons on each level shall be one per seating place provided (at 500 mm wide) and not more than four per square metre of other areas;

— (LC1) LCG of the crew at 75 % of the maximum overall length of the crew area (as defined in B.3.1.7) forward of its aft limit, and CG on the centreline;

— (LC2) LCG of the crew at 25 % of the maximum overall length of the crew area (as defined in B.3.1.7) forward of its aft limit, and CG on the centreline.

The maximum overall length of the crew area is the simple longitudinal distance between the forward and aft extremities of the crew area. The lengths of different parts should not be added together.

B.3.2.3 Calculate the curve of righting moments according to Annex E.

B.3.2.4 Calculate the curve of crew heeling moments equal to $961CL(B_C/2 - 0{,}2)\cos\phi$ (N·m), where B_C is the maximum transverse distance between the outboard extremities of any parts of the crew area as defined in B.3.1.7, and ϕ is the heel angle. Where the crew area includes side decks less than 0,4 m wide, the moment used shall be $480CL\,B_C\cos\phi$ (N·m). Ledges less than 0,10 m wide can be excluded from the crew area.

B.3.2.5 Plot righting moments and heeling moments on the same graph. The boat satisfies the test if the following are satisfied.

— For design category C and D boats (except those complying with the buoyant volume requirements in ISO 6185): at the point of intersection of these curves the minimum freeboard margin before downflooding (see Annex D) is not less than required in Table 5, whether obvious to the crew (e.g. over the gunwale) or not obvious (e.g. through openings in the topsides).

— At the point of intersection of these curves, the heel angle (degrees), ϕ_O, does not exceed

$$11{,}5 + \frac{(24 - L_H)^3}{520}, \qquad \text{(B.1)}$$

see also Table 4. This event shall be ignored for design category D boats that are not fully enclosed.

— The maximum righting moment occurring up to the downflooding angle is greater than the heeling moment at the offset-load test heel angle, ϕ_O.

B.3.3 Full procedure for offset-load test

B.3.3.1 This method can be applied by either physical test or by calculation. Calculation shall replicate the physical test method described below.

B.3.3.2 Prepare a set of test weights totalling 85 kg for each person up to the desired crew limit. Then test the boat according to B.3.3.3. Where the crew limit is expected to exceed seven persons, up to 25 % of the crew limit can be added at each of the first two stages a) and c) below. Increments for the following stages shall not exceed one person.

NOTE 1 The use of water containers instead of metallic test weights will give a less advantageous result. The use of persons might give a less advantageous result but be more convenient to test.

NOTE 2 85 kg includes a margin of 13 % to allow for the probability that a group of persons might weigh on average more than 75 kg each.

Test weights totalling 98 kg for each person may be used, but the resulting test is more conservative.

NOTE 3 See B.3.3.3 e) 3).

B.3.3.3 The following procedure shall be followed.

a) With the boat in the maximum load condition except for the crew and except that the tanks are filled as in B.3.1.3, place the first set of test weights to one side of the crew area, but with their centre of gravity not closer than 200 mm from the outboard edge of the crew area, in the position that results in the maximum heel angle, investigating positioning test weights on various deck levels within the crew area and at various longitudinal locations to ensure that the worst case is found. Measure the heel angle and freeboard margin (see Annex C). Where the crew area includes side decks less than 0,4 m wide, test weights shall be placed at mid-width of such decks.

b) If necessary, repeat in the opposite direction of heel. Where both directions are tested, the most adverse of the two measurements made of each parameter are to be recorded.

c) Place the next set of test weights to one side of the crew area, in the position that results in the maximum heel angle, investigating positioning test weights on various deck levels within the crew area and at various longitudinal locations to ensure that the worst case is found. The centre of gravity of the sets of test weights shall be positioned as far to one side as practicable, provided that adjacent sets of test weights are not placed with their centres of gravity closer than 500 mm apart in any direction, or with their centre of gravity closer than 200 mm from the outboard edge of the crew area. Where the crew area includes side decks less than 0,4 m wide, test weights shall be placed at mid-width of such decks.

d) Measure the heel angle and least freeboard margin. If necessary, repeat in the opposite direction of heel. Where both directions are tested, the most adverse of the two measurements made are to be recorded;

e) Repeat c) and d) for further increments of not more than one set of test weights at a time, while observing the manufacturer's definition of crew area according to B.3.1.7. Stop the test when the first of the following events happens.

   1) For design category C and D boats, the minimum freeboard margin before downflooding is reached (see Annex D) according to Table 5, whether obvious to the crew (e.g. over the gunwale) or not obvious to the crew (e.g. through downflooding openings in the topsides). This event can be ignored for boats complying with the buoyant volume requirements of ISO 6185 and employing this test.

   2) The heel angle (degrees) is about to exceed

$$11{,}5+\frac{\left(24-L_{\mathrm{H}}\right)^{3}}{520}\ , \tag{B.2}$$

see also Table 4. This event shall be ignored for design category D boats that are not fully-enclosed.

3) The total mass of test weights on board reaches 98 kg per person for the desired crew limit.

NOTE 98 kg per person is used here to ensure that a safety margin is achieved against sudden loss of stability.

4) The heel angle suddenly increases a large amount for a small increase in heeling moment. This is when the boat is close to a complete loss of residual stability and consequent capsize.

CAUTION 1 — Great caution must be exercised when doing this test because some boats may capsize suddenly. Therefore heeling moments should be increased carefully, especially when approaching the expected crew limit. As this point is approached, smaller increments of test weights should be used. In smaller boats it is helpful to attach a capsize preventer rope (e.g. from the depressed gunwale to a strong point ashore) provided that this is kept slack enough not to interfere with the test. For larger boats, to give warning of loss of stability, a continuously plotted graph of heel angle against heeling moment (product of the mass of test weights times the distance off the centreline measured parallel to the deck) should be used.

CAUTION 2 — Because of the risk of capsize, persons should not be used instead of sets of test weights in any locations from which escape after capsize would be hazardous.

f) Of the measurements made according to a), b), d) or e), the maximum heel angle recorded shall be less than that required in e) above, and the minimum measured freeboard margin recorded shall exceed the requirement for the appropriate option as given in Table 5.

g) If the test is limited by downflooding that is obvious to the crew (e.g. over the gunwale), the crew limit corresponds to the maximum mass of test weights divided by 85 kg, and rounded downward to the nearest whole number.

h) If the test is limited by maximum heel angle, loss of stability or downflooding that is not obvious to the crew (e.g. through openings in the topsides), the crew limit corresponds to the maximum mass of test weights divided by 98 kg and rounded downward to the nearest whole number.

NOTE 98 kg per person is used here to ensure that a safety margin is achieved against sudden loss of stability.

i) After completion of testing according to a) to h), the sets of test weights shall be moved to the positions (using the criteria of c) above) that result in the least freeboard margin. If the measured freeboard does not satisfy Table 5, sets of test weights shall be removed until this is achieved, while maintaining the most adverse positioning of the remainder.

j) The final crew limit shall be that which complies with both the procedure described in a) to h) and that given in i) above.

B.3.4 Additions of top-weight

Because additions of top-weight can dramatically affect ϕ_{O}, the test and/or calculations shall be undertaken for any boat that deviates substantially from the standard outfit. In particular, masts, radar antennae, equipment and sail furling gear can significantly affect the stability. The effects of such variations from a boat on which a test has been performed might be determined by calculation using the mass and coordinates of the variations.

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

$$\sum(m,h)\ > 0{,}02 B_{\mathrm{H}} m_{\mathrm{LDC}} \tag{B.3}$$

where

$\sum(m,h)$ 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 by physical test

Test weights or persons can be used to represent the mass of the crew. Where persons are used, the moment applied shall be calculated using their actual masses. If standing, they shall stand with feet together and maintain their balance without using handholds unless this is essential for their safety.

When applying the heeling moments according to B.3.3.3, the vertical position of the crew can either be represented by persons or by test weights placed on top of seats, or on the deck where the people are assumed to be standing.

When recording the heel angle of the boat, people engaged in measuring this shall return to the same position on board each time that measurements are recorded. Heeled freeboard margin shall be measured by a person not on board the boat being tested.

CAUTION — Great care should be taken during the test to avoid capsize or sinking. Refer to the cautions given in B.3.3.3 e).

B.5 Application by calculation

B.5.1 For the simplified method, follow the requirements of B.3.2.

B.5.2 For the full method of B.3.3, the procedure is as set out below.

a) Calculate a series of loading conditions each representing the possible placement of each set of test weights, including the free-surface correction to the VCG, but ignoring the effect of the crew on the transverse centre of gravity. The VCG of each person shall be taken as 0,1 m above each seat or for standing persons 0,1 m above the surface on which they stand.

b) Calculate curves of righting moments for the boat in each of the conditions prepared according to a), for a range of relevant heel angles using the methods of Annex E. Therefore a separate righting moment curve will be required for each successive stage of B.3.3.

c) Calculate the curve of crew heeling moments appropriate to each loading condition derived in a) above using:

1) heeling moment (N·m) at heel angle

$$\phi = 834 \cos\phi \, \Sigma(y_n) \qquad \text{(B.4)}$$

for freeboard margin against downflooding that is obvious to the crew (e.g. over the gunwale),

2) heeling moment (N·m) at heel angle

$$\phi = 961 \cos\phi \, \Sigma(y_n) \qquad \text{(B.5)}$$

for heel angle, loss of stability and freeboard margin against downflooding that is not obvious to the crew (e.g. through downflooding openings in the topsides),

where

$\Sigma(y_n)$ is the sum of the distances off the centreline of the boat of each person being represented, measured at right-angles to the centreline plane.

d) Plot righting moments and heeling moments on the same graph. The boat satisfies the test if the following are satisfied:

1) For design category C and D boats: at the point of intersection of these curves the minimum freeboard margin before downflooding (see Annex D) is not less than required in Table 5, whether obvious to the crew (e.g. over the gunwale) or not obvious (e.g. through openings in the topsides).

2) At the point of intersection of these curves the heel angle (degrees), ϕ_O, does not exceed $11{,}5 + [(24 - L_H)^3 / 520]$, see also Table 4.

3) The maximum righting moment occurring up to the downflooding angle is greater than the heeling moment at the resulting heel angle, ϕ_O.

Annex C
(normative)

Methods for calculating downflooding angle

C.1 Choice of method

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

C.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.

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

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

$$\phi_D = \tan^{-1}\left(z_D / y'_D\right) \quad \text{(C.1)}$$

ϕ_D is the angle whose tangent is $\left(z_D / y'_D\right)$ (C.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 centreline of the boat.

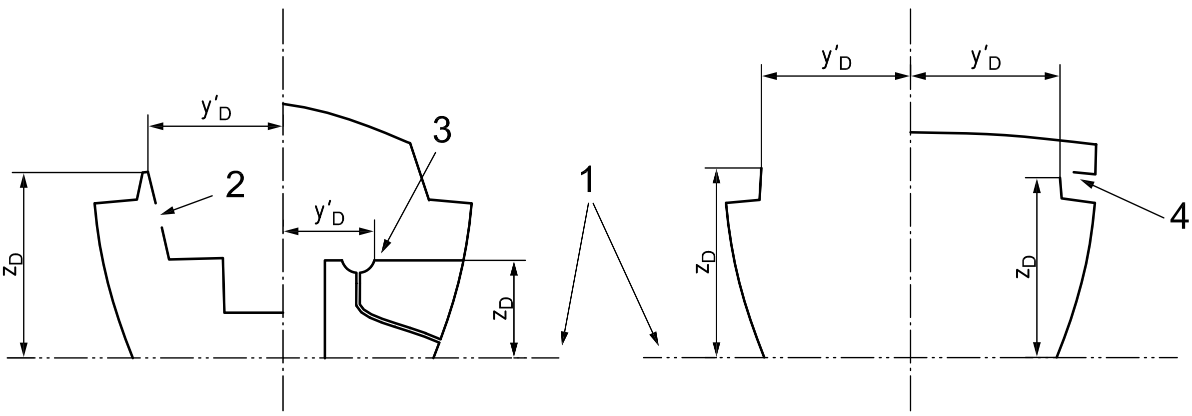
See Table C.1 and Figure C.1.

Table C.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

Table C.1 *(continued)*

z_D/y'_D	ϕ_D degrees
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 C.1 — Approximate method for downflooding angle

Annex D
(normative)

Method for measuring freeboard margin

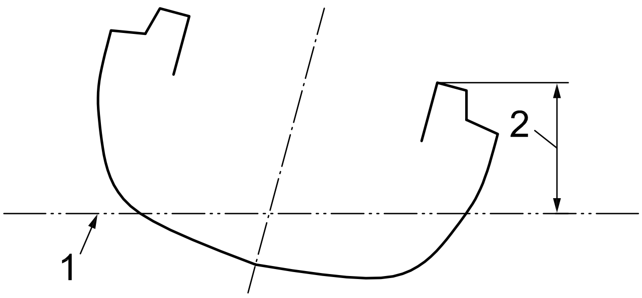
D.1 Definition

The freeboard margin to be measured during the offset-load test is the least height when the boat is heeled from the waterline to the point at which water first enters the interior, bilge or non-quick-draining part of the boat, taking account of any tubes or ducts inside the hull.

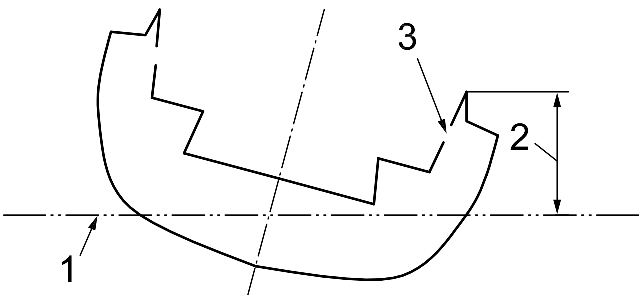
Where openings are protected by a higher coaming or sill, this height shall be measured to the lowest point of water ingress of that coaming or sill when the boat is heeled during the test.

See examples in Figure D.1.

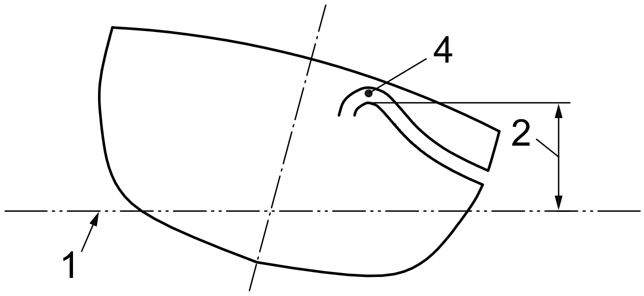
D.2 Examples



a) Boat with a wide coaming



b) Boat with a “protected” opening



c) Boat with a piped or ducted opening

Key

1 waterline

2 freeboard margin

3 downflooding opening protected by coaming

4 downflooding point in ducted opening

Figure D.1 — Measurement of freeboard margin

Annex E
(normative)

Determining the curve of righting moments

E.1 Method

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

E.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.

E.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 loading condition;

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 %.

E.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 3.5.7), 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 ($F_M + T_C$).

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 might result. It can, however, be used for preliminary assessment.

For the purposes of determining the curve of righting moments, the vertical disposition of the mass of the crew shall be

— as required by Annex B for calculations to show compliance with 6.2, or

— as required by 6.3.1 for calculations to show compliance with 6.3.

E.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) methods b) or c) in E.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.

E.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 E.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 E.1 — Contents of tanks for calculation of righting moments

Tank	Loading condition		
	Loaded arrival	Offset-load test	Minimum operating
Fuel	10 %	50 %	0 %
Fresh water	10 %	50 %	0 %
Black/grey water	95 %	50 %	0 %
Oils	10 %	50 %	0 %
Bait tanks, live wells	95 %	50 %	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.

virtual increase in the boat's VCG due to each tank =

$$\frac{\text{SMA}_{\text{TANK}} \times \rho_{\text{TANK}}}{m} \text{, expressed in metres} \tag{E.1}$$

where

ρ_{TANK} is the density of fluid in tank, expressed in kilograms per cubic metre;

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.

E.3 Determination by rigorous calculation

E.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 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.

E.3.2 In defining the watertight hull, cockpits, recesses, bow thruster tunnels and all appendages affecting the buoyancy shall be correctly represented. Righting moment 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 moments to be used to show compliance with 6.3 and 6.5 can alternatively be calculated ignoring flooding of recesses through either

— freeing ports equipped with non-return flap closures 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.

NOTE Righting moments to be used to show compliance with 6.2 must assume flooding may occur through all openings.

E.3.3 The buoyancy of superstructures and deckhouses might 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°.

E.3.4 The buoyancy of masts and standing rigging (but not booms, gaffs or running rigging) might 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.

E.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.

E.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).

Annex F
(normative)

Method for level flotation test

F.1 General

The methods described in F.2, F.3 and F.4 shall be used, either by actual test or equivalent calculation.

F.2 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 on the interior deck, on the centreline at $L_H/2$.

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

c) For outboard engines, the builder's maximum recommended power shall be used. Tables F.1 and F.2, columns 2 and 4 give the appropriate replacement mass to be used with respect to engine power for petrol engines. A heavier mass can 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 lead, steel or iron of a mass equal to 75 % of the installed mass of the engine and stern-drive.

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 removed, or shall be full with either fuel or 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 G 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 that have laminated, glued, welded or bolted seams in their construction, and which air tanks do not comply with the enhanced pressure test of Annex G, shall have a number of air chambers opened to atmosphere during testing, according to Table F.3.

Table F.1 — Mass of single-engine installations

Engine power kW	Engine + controls kg		Battery kg	
	Column 1 Dry	Column 2 Swamp	Column 3 Dry	Column 4 Swamp
0 to 1,5	13,7	11,7	—	—
1,6 to 2,9	18,2	15,5	—	—
3,0 to 5,2	40,9	34,8	—	—
5,3 to 11,2	60,0	51,0	9,1	5,0
11,30 to 18,7	104,5	88,9	20,5	11,4
18,8 to 33,6	124,1	106,2	20,5	11,4
33,7 to 44,8	161,7	138,2	20,5	11,4
44,9 to 56,0	188,5	161,0	20,5	11,4
56,1 to 74,6	207,6	177,2	20,5	11,4
74,7 to 108,2	258,6	220,5	20,5	11,4
108,3 to 164,1	260,7	222,3	20,5	11,4
164,2 and over	312,5	266,3	20,5	11,4
NOTE Power in kW = (Imperial horsepower) × 0,745 7 Imperial horsepower = (Power in kilowatts) × 1,341 Power in kilowatts = (Metric horsepower) × 0,735 5 Metric horsepower = (Power in kilowatts) × 1,360				

Table F.2 — Mass of twin-engine installations

Total engine power kW	Engine + controls kg		Battery kg	
	Column 1 Dry	Column 2 Swamp	Column 3 Dry	Column 4 Swamp
37,6 to 67,2	247,9	212,2	40,9	22,7
67,3 to 89,6	323,3	276,2	40,9	22,7
89,7 to 112,0	376,8	321,8	40,9	22,7
112,1 to 149,2	415,0	354,2	40,9	22,7
149,3 to 216,4	517,1	440,9	40,9	22,7
216,5 to 328,2	521,2	444,5	40,9	22,7
328,3 and over	624,9	532,5	40,9	22,7

Table F.3 — Number 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

F.3 Swamped stability test

F.3.1 A metallic test weight with a dry mass of ($6d$CL) kg but always more 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 F.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, apart from those required by F.2.

F.3.2 d is a coefficient to account for the buoyancy of the test weight, as given in Table F.4. Where test weights are not all of the same material, the calculation shall be similar to

$$\frac{m_{LD}}{1{,}099} + \frac{m_{CI}}{1{,}163} + \frac{m_{AL}}{1{,}612} = 6CL \quad \text{(F.1)}$$

where

m_{LD} is the mass of lead weights, expressed in kilograms;

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

m_{AL} is the mass of aluminium weights, expressed in kilograms.

F.3.3 As an alternative to suspending a test weight over the side, an equivalent heeling moment (calculated when the boat is upright) can be applied using weights or persons positioned inside the boat at seat level. Persons can only be used if they are not immersed when the boat is heeled.

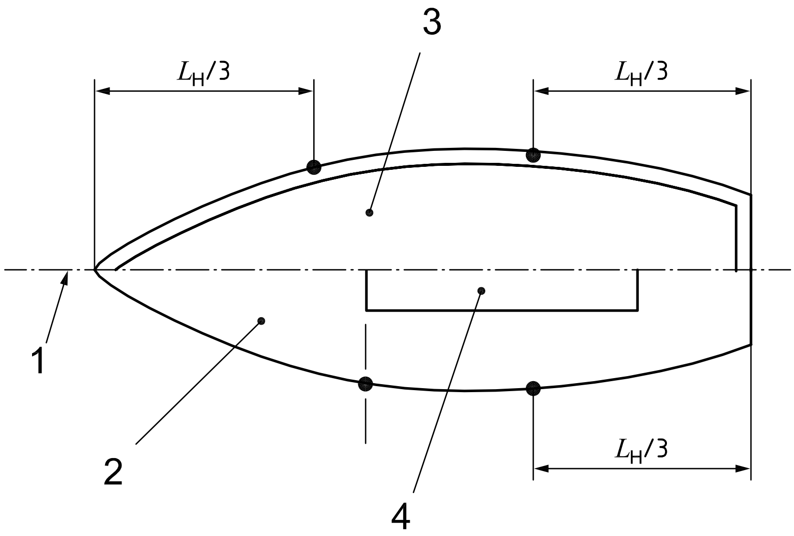
F.3.4 With the test weight in each position in turn, swamp the boat by applying a downwards force at a position on the gunwale at approximately mid-L_H until the deepest point of the gunwale or coaming is 0,2 m below the water surface. Hold the boat in this position until the water level has equalized between inside and outside, or for 5 min, whichever is less, and then release the boat.

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

F.3.5 For each position of the test weights, after a further 5 min have elapsed, the boat shall not heel more than 45°.

Table F.4 — Material coefficient

Property	Material				
	Lead	65/35 brass	Steel	Cast iron	Aluminium
Value of d	1,099	1,138	1,151	1,163	1,612



Key

1 centreline
2 deck
3 open boat
4 cockpit

Figure F.1 — Positioning test weights

F.4 Swamped buoyancy test

F.4.1 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 F.5. This area shall have a minimum headroom clearance of 0,6 m above the swamped waterline. Alternatively, provided they are not immersed above the knee, people can be used instead of test weights, provided they have a total dry mass not less than the required mass of test weights if d is taken as 1,1.

Table F.5 —Mass of load test weights

Property	Design category		
	B	C	D
Dry mass (kg) not less than	$d(0{,}33m_{LC} + 100CL + m_{MISC} + 0{,}33m_{TANKS})^{a,b}$	$d(60 + 15CL)$	$d(50 + 10CL)$
[a] m_{TANKS} is the mass of portable fuel tanks when full, expressed in kilograms.			
[b] m_{MISC} is the dry mass of stores and equipment included in the maximum load, expressed in kilograms.			

F.4.2 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 0,2 m below the water surface. Hold the boat in this position until the water level has equalized between inside and outside, or for 5 min, whichever is less, and then release the boat.

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

F.4.3 After a further 5 min 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 The values of the formulae given in F.3.1 and F.4.1 are given in Table F.6.

Table F.6 —Mass of test weights

Mass in kilograms

Formula	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 + 15CL) =	75*d*	90*d*	105*d*	120*d*	135*d*	150*d*	165*d*	180*d*	195*d*	210*d*
d(50 + 10CL) =	60*d*	70*d*	80*d*	90*d*	100*d*	110*d*	120*d*	130*d*	140*d*	150*d*

Annex G
(normative)

Flotation material and elements

G.1 Requirements

Flotation elements as defined in 3.5.6 shall comply with the requirements in Table G.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 nevertheless contribute to the flotation characteristics shall not be subject to the requirements in this annex.

Table G.1 — Requirements for flotation elements

Property	Air tank	Air container	Inflated bag	Low density material
Airtightness	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 to withstand buoyancy force	—	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 that this property is required but is not subject to a specific test by the builder.

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

G.2 Tests

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

NOTE Materials complying with the requirements of IMO Resolution MSC.81(70) Part 1[4], Clauses 2.7.5 to 2.7.8 are deemed to satisfy this requirement.

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 G.2.

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, shall have a number of air chambers opened to atmosphere during testing, according to Table F.3.

Table G.2 — Test pressures

Condition	Enhanced pressure test	Basic pressure test
Chambers required to be opened during flotation tests	None	As detailed in Table F.3
Initial over-pressure	2,5 kPa (250 mm water)	1,25 kPa (125 mm water)
Maximum pressure drop in 30 s	1,0 kPa (100 mm water)	0,75 kPa (75 mm water)

Breather holes in air tanks designed for the relief of air pressure due to variations in ambient temperature can 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 F.

Annex H
(normative)

Information for owner's manual

H.1 General information

The following stability information, as appropriate to the design, shall be included in the owner's manual as defined in ISO 10240.

A maximum load has been used for assessing stability and buoyancy comprising

— manufacturer's maximum recommended load per ISO 14946	.... kg
— fuel, fresh water, other fluids to maximum capacity of fixed tanks	.... kg
Maximum load	.... kg

This assessment has been made assuming that

— the boat in the empty craft condition has a mass of	.... kg
— the boat in the light craft condition has a mass of	.... kg
— the maximum recommended outboard engine mass is	.... kg
— all standard equipment is aboard.	

H.2 Specific information

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

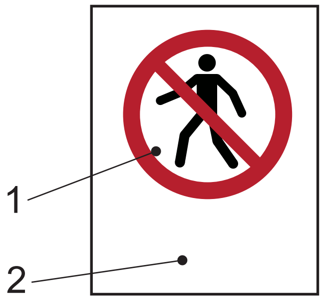
a) This boat has been assessed as capable of supporting the crew even when swamped (*when meeting the requirements of 6.8*).

b) The following openings are marked "KEEP SHUT WHEN UNDER WAY", and care shall be taken to observe this warning: (*insert list of relevant opening locations*). "Under way" has the meaning "not at anchor, or made fast to the shore, or aground". (*Text to be inserted when required according to 6.1.1.6*).

c) IMPORTANT: Failure to observe these limitations may result in the boat capsizing.

Where certain parts of the boat have had crew access restricted by the offset-load test, the following text shall be included, as appropriate:

d) For stability reasons, the following parts of the boat should only be accessed by people in exceptional circumstances: *(insert list of relevant locations)*. Such locations are indicated by the safety sign in Figure H.1.



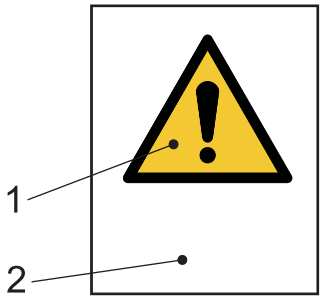
Key

1 sign P004 “No thoroughfare” from ISO 7010

2 supplementary text to read “No access”

Figure H.1 — No access sign

e) For stability reasons, the following parts of the boat should only be accessed by more than the indicated number of persons in exceptional circumstances: *(insert list of relevant locations, e.g. deck, coachroof, flybridge, and limit on each location)*. Such locations are indicated by the safety sign in Figure H.2 and/or a sign at each control position.



Key

1 sign W001 “General warning” from ISO 7010

2 supplementary text to read “Max N persons on (location)” where N is the relevant number and (location) is expressed for example as “flybridge” or “coachroof”

Figure H.2 — Limited access sign

Annex I
(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 summarized in Table I.1.

Table I.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	—	—	—	—
	partially protected	—	—	—	—	—	—	—	yes	yes	—	—
	not fully enclosed	—	—	—	—	—	—	—	—	—	yes	yes
	fully enclosed	yes	yes	yes	yes	—	—	—	—	—	—	—
Downflooding openings comply (6.1.1)		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Required downflooding height (6.1.2) (using figures)	$h_{D(R)} >$	0,5	0,4	0,353	0,3	0,4	0,3	0,25	0,5	0,4	0,6	0,4
	$h_{D(R)}$ to be >	$L_H/17$	$L_H/17$	$L_H/17$	$L_H/20$	$L_H/17$	$L_H/20$	$L_H/24$	$L_H/12$	—	$L_H/10$	—
	$h_{D(R)}$ need not be >	1,41	1,41	0,75	0,4	1,41	0,75	0,4	0,75	—	0,75	—
Required 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 > $\phi_{D(R)}$ =	$\phi_O + 25$	$\phi_O + 15$	—	—	$\phi_O + 15$	—	—	—	—	—	—
	or if greater =	30°	25°	—	—	25°	—	—	—	—	—	—
Offset load (6.2)	$\phi_O < \phi_{O(R)}$ =	$11{,}5 + (24 - L_H)^3/520$										
	residual freeboard to be >	—	—	$0{,}014L_H$	0,010	—	$0{,}014L_H$	0,010	$0{,}11\sqrt{L_H}$	$0{,}07\sqrt{L_H}$	$0{,}11\sqrt{L_H}$	$0{,}07\sqrt{L_H}$
Rolling in waves (6.3.2)	when v_W (m/s) =	28	21	—	—	21	—	—	—	—	—	—
	$A_2 \geq A_1$ when ϕ_R =	$25 + 20/V_D$	$20 + 20/V_D$	—	—	$20 + 20/V_D$	—	—	—	—	—	—
Resistance to waves (6.3.3)	If $\phi_{GZmax} \geq 30°$, RM_{30} to be ≥	25 kN·m	7 kN·m	—	—	7 kN·m	—	—	—	—	—	—
	If $\phi_{GZmax} \geq 30°$, GZ_{30} to be ≥	0,20 m	0,20 m	—	—	0,20 m	—	—	—	—	—	—
	If $\phi_{GZmax} < 30°$, RM_{max} to be ≥	$750/\phi_{GZmax}$ kN·m	$210/\phi_{GZmax}$ kN·m	—	—	$210/\phi_{GZmax}$ kN·m	—	—	—	—	—	—
	If $\phi_{GZmax} < 30°$, GZ_{max} to be ≥	$6/\phi_{GZmax}$ m	$6/\phi_{GZmax}$ m	—	—	$6/\phi_{GZmax}$ m	—	—	—	—	—	—
Heel due to wind (6.4) *only if* $A_{LV} > 0{,}55 L_H B_H$	when v_W (m/s) =	—	—	17	13	—	17	13	17	13	17	13
	wind heel angle ϕ_W <	—	—	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	—	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$	$0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$
Recess size (6.5)	max % loss in GM_T	$250F_R/L_H$	$550F_R/L_H$	$1200F_R/L_H$	—	—	—	—	—	—	—	—
Habitable multihulls (6.6)		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Motor sailers (6.7)	for v_W (m/s) =	18	14	—	—	—	—	—	—	—	—	—
	M_W <	0,5 GZ_{max}	0,5 GZ_{max}	—	—	—	—	—	—	—	—	—
Flotation tests (6.8)	none required	yes	yes	yes	yes	—	—	—	yes	yes	yes	yes
	required	—	—	—	—	yes	yes	yes	—	—	—	—
Detection & removal of water (6.9)		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Annex J
(informative)

Worksheets

The following worksheets are provided to assist in the systematic assessment of a boat according to this part of ISO 12217.

ISO 12217-1 NON-SAILING BOATS OF LENGTH GREATER THAN OR EQUAL TO 6 m

CALCULATION WORKSHEET No. 1

Design: ....

Design category intended:	Monohull / multihull:			
Item	**Symbol**	**Unit**	**Value**	**Ref.**
Length of hull as in ISO 8666	L_H	m		3.3.1
Length waterline in loaded arrival condition	L_{WL}	m		3.3.2
Empty craft condition mass	m_{EC}	kg		3.4.1
standard equipment		kg		3.5.12
water ballast in tanks which are notified in the owner's manual to be filled whenever the boat is afloat		kg		3.4.2
Light craft condition mass = m_{EC} + standard equipment + ballast	m_{LC}	kg		3.4.2
Mass of:				
Desired Crew Limit	CL	—		3.5.3
Mass of:				
desired Crew Limit at 75 kg each		kg		3.4.4
provisions + personal effects		kg		3.4.4
drinking water		kg		3.4.4
fuel		kg		3.4.4
lubricating and hydraulic oils		kg		3.4.4
black water		kg		3.4.4
grey water		kg		3.4.4
any other fluids carried aboard (e.g. in bait tanks)		kg		3.4.4
stores, spare gear and cargo (if any)		kg		3.4.4
optional equipment and fittings not included in basic outfit		kg		3.4.4
inflatable liferaft(s) in excess of essential safety equipment		kg		3.4.4
other small boats carried aboard		kg		3.4.4
margin for future additions		kg		3.4.4
Maximum load = sum of above masses	m_L	kg		3.4.4
Maximum load condition mass = m_{LC} + m_L	m_{LDC}	kg		3.4.5
mass to be removed for loaded arrival condition		kg		3.4.6
Loaded arrival condition mass	m_{LA}	kg		3.4.6
Mass of:				
minimum number of crew according to 3.4.3		kg		3.4.3a)
non-consumable stores and equipment normally aboard		kg		3.4.3b)
inflatable liferaft		kg		3.4.3
Load to be included in minimum operating condition	m'_L	kg		3.4.3
Light craft condition mass	m_{LC}	kg		3.4.2
Mass in the minimum operating condition = m_{LC} + m'_L	m_{MO}	kg		3.4.3
Is boat sail or non-sail?				3.1.2, 5.2
reference sail area according to ISO 8666	A_S	m^2		3.3.8
sail area / displacement ratio = $A_S/(m_{LDC})^{2/3}$		—		3.1.2, 5.2
CLASSIFIED AS [non-sail if $A_S/(m_{LDC})^{2/3} < 0,07$]		SAIL/NON-SAIL?		3.1.2, 5.2
NB: If NON-SAIL, continue using these worksheets, if SAIL, use ISO 12217-2				
GO TO WORKSHEET No. 2				

ISO 12217-1 CALCULATION WORKSHEET No. 2 TESTS TO BE APPLIED

Question			Answer	Ref.
Is boat fully enclosed?	(see definition in ref.)	YES/NO?		3.1.6
Is boat partially protected?	(see definition in ref.)	YES/NO?		3.1.7

Item	Symbol	Unit	Value	Ref.
Windage area in minimum operating condition	A_{LV}	m[2]		3.3.7
Length waterline in loaded arrival condition	L_{WL}	m		3.3.2
Beam of hull	B_H	m		3.3.3
Ratio $A_{LV}/(L_{WL}\ B_H)$		—		

Choose any ONE of the following options, and use all the worksheets indicated for that option.

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 enclosed	fully enclosed	any amount	any amount	partially protected	any amount
downflooding openings		3	3	3	3	3	3
downflooding angle		3		3			
downflooding height test	all boats	3	3	3	3 [a]	3	3
	Annex A method	4	4	4	4 [a]	4	4
offset load test		5	5	5	5	5	5
resistance to waves + wind		6		6			
heel due to wind action			7 [b]		7 [b]	7 [b]	7 [b]
recess size		8	8 [c]				
habitable multihulls		9	9	9	9	9	9
motor sailers		9	9	9	9	9	9
flotation test				10	10		
flotation material				10	10		
detection & removal of water		11	11	11	11	11	11
SUMMARY		12	12	12	12	12	12

[a] The downflooding height test is not required to be conducted on the following design category C and D boats:

— those which, when tested in accordance with F.4, have been shown to support, in addition to the mass required by F.2 and Table F.5, an additional equivalent dry mass (kg) of (75CL + 10 % of dry mass of stores and equipment included in the maximum total load), or

— those boats that do not take on water when heeled to 90° from the upright in the light craft condition.

[b] The application of Worksheet 7 is only required for boats where $A_{LV}/(L_{WL}\ B_H) > 0{,}5$.

[c] Only required for boats of design category C.

Option selected	

ISO 12217-1 CALCULATION WORKSHEET No. 3 — DOWNFLOODING

Downflooding openings: (all boats)

Question		Answer	Ref.
Have all appropriate downflooding openings been identified?	YES/NO		3.2.1
Have potential downflooding openings within the boat been identified?	YES/NO		6.1.1.4
Do all closing appliances satisfy ISO 12216?	YES/NO		6.1.1.1
Hatches or opening type windows are not fitted below minimum height above waterline?	YES/NO		6.1.1.2
Seacocks comply with requirements?	YES/NO		6.1.1.3
Are all openings on design category A or B boats fitted with closing appliances? (Except openings for ventilation and engine combustion)	YES/NO		6.1.1.5
Design categories possible: A or B if all are YES, C or D if first five are YES			6.1.1

Downflooding angle: (design categories A and B only)

Item		Symbol	Unit	Value	Ref.
Required value: (where ϕ_O = attained angle from offset load test)					6.1.3
Design category A = larger of (ϕ_O + 25)° or 30°		$\phi_{D(R)}$	degrees		Table 3
Design category B = larger of (ϕ_O + 15)° or 25°		$\phi_{D(R)}$	degrees		Table 3
Area of openings permitted to be submerged = $1{,}2 L_H B_H F_M$			cm^2		6.1.3
Actual downflooding angle:	at mass = m_{MO}	ϕ_{DA}	degrees		6.1.3
	at mass = m_{LA}	ϕ_{DA}	degrees		6.1.3
Method used to determine ϕ_{DA}:					Annex C
Design category possible on downflooding angle					6.1.3

Downflooding height: (all except exempt boats)

Requirement			Basic requirement	Reduced value for small openings	Reduced value at outboard	Increased value at bow
applicable to			all options	all options but only if figures are used	options 3, 4	options 3, 4, 6
ref.			6.1.2.2 a)	6.1.2.2 d)	6.1.2.2 c)	6.1.2.2 b)
obtained from Figs. 2 + 3 or Annex A?				= basic × 0,75	= basic × 0,80	= basic × 1,15
maximum area of small openings ($50 L_H^2$) (mm^2) =						
Required downflood height $h_{D(R)}$ (m)	Fig. 3/An'x A	Category A				
	Fig. 3/An'x A	Category B				
	Fig. 3/An'x A	Category C				
	Fig. 4/An'x A	Category D				
Actual downflooding height h_D						
Design category possible						
Design category possible on downflooding height = lowest of above						

ISO 12217-1 CALCULATION WORKSHEET No. 4 DOWNFLOODING HEIGHT

Calculation using Annex A assuming use of option ………

Item		Sym-bol	Unit	Opening 1	Opening 2	Opening 3	Opening 4
Position of openings:							
Least longitudinal distance from bow/stern		x	m				
Least transverse distance from gunwale		y	m				
F_1 = greater of $(1 - x/L_H)$ or $(1 - y/B_H)$ =		F_1	—				
Size of openings:							
Total combined area of openings to top of any downflooding opening		a	mm²				
Longitudinal distance of opening from tip of bow		x'_D	m				
Limiting value of $a = (30L_H)^2$			mm²				
If $a \geq (30L_H)^2$, $F_2 = 1{,}0$ If $a < (30L_H)^2$, $F_2 = 1 + \frac{x'_D}{L_H}\left(\frac{\sqrt{a}}{75L_H} - 0{,}4\right)$		F_2	—				
Size of recesses:							
Volume of recesses which are not quick-draining in accordance with ISO 11812		V_R	m³				
Freeboard amidships (see 3.3.5)		F_M	m				
$k = V_R/(L_H B_H F_M)$		k	—				
If opening is not a recess, $F_3 = 1{,}0$ If recess is quick-draining, $F_3 = 0{,}7$ If recess is not quick-draining, $F_3 = (0{,}7 + k^{0{,}5})$		F_3	—				
Displacement:							
Loaded displacement volume (see 3.4.5)		V_D	m³				
$B = B_H$ for monohulls, B_{WL} for multihulls		B	m				
$F_4 = [(10\ V_D)/(L_H \cdot B^2)]^{1/3}$		F_4	—				
Flotation:							
For boats using option 3 or 4, $F_5 = 0{,}8$ For all other boats, $F_5 = 1{,}0$		F_5	—				
Required calc. height: $= F_1 F_2 F_3 F_4 F_5\ L_H/15$		$h_{D(R)}$	m				
Required downflooding Height with Limits applied (see Annex A, Table A.1)	Category A	$h_{D(R)}$	m				
	Category B	$h_{D(R)}$	m				
	Category C	$h_{D(R)}$	m				
	Category D	$h_{D(R)}$	m				
Measured downflooding height:		h_D	m				
Design category possible:							
lowest of above =							

ISO 12217-1 CALCULATION WORKSHEET No. 5 OFFSET-LOAD TEST

Mass of people used for test

Name	Ident.	Mass (kg)
	A	
	B	
	C	
	D	
	E	
	F	
	G	
	H	

Name	Ident.	Mass (kg)
	I	
	J	
	K	
	L	
	M	
	N	
	O	
	P	

Crew area

Areas included and access limitations (if any):

Area	P/S? [a]	Incl?	Persons limit
main cockpit		√	
aft cockpit			
forward cockpit			
saloon			
cabins			
side decks			
fore deck			

Area	P/S? [a]	Incl?	Persons limit
cuddy top			
coachroof top			
wheelhouse top			
fly bridge			
swim platform			

[a] Note whether it is asymmetric by adding P (port) or S (starboard) to denote the larger side.

Sketch: Indicate possible seating locations along the length of the side to be tested using numbers, so that these may later be used to record the positions that people actually occupy. Locations should not be closer than 0,5 m between centres, and not closer to outboard edge than 0,2 m unless on side-decks less than 0,4 m wide.

ISO 12217-1 CALCULATION WORKSHEET No. 5 (*continued*) OFFSET LOAD TEST

Stability test — Full procedure **(Sheet to be used twice: once for stability, then for flooding)**

Boat being tested for:	**stability**	**downflooding**	(use for either, please circle which)			
L_H (m)	**Min. permitted freeboard margin (see Table 5)**	**Max. permitted heel angle** (°) $= 11{,}5 + \frac{(24 - L_H)^3}{520}$	**Table 1 — Intended Crew Limit (CL)**	**Intended design category**	**Mass test weights per person** (kg) **(Cat D only)**	**Max. mass of test weights** (kg) **(= 98 × CL)**

Does boat have a list?	YES/NO	**If "YES", to which side?**	P / S
Is crew area asymmetric?	YES/NO	**If "YES", to which side?**	P / S
Is downflooding asymmetric?	YES/NO	**If "YES", to which side?**	P / S
Boat tested: **to P** **to S** **in both directions**	(please circle)		

Test data:

Mass Iden.	**Location**		**Mass** (kg)	**Total mass** (kg)	**Lever** (m)	**Moment** (kgm)	**Heel angle** (°) P/S	**Min. freeboard** (m)	
	area	**fore & aft**						**forward**	**aft**

Max mass of people allowed per above kg	hence CL =		at kg/person

Design category given:

Safety signs required:	**Fig. B.1 YES/NO**	**Fig. B.2 YES/NO**	**Fig. B.3 YES/NO**

ISO 12217-1 CALCULATION WORKSHEET No. 5 (*continued*)
SIMPLIFIED OFFSET LOAD TEST

This method may only be applied by calculation; requirements must be fulfilled for both conditions LC1 and LC2.

Preparation (curves of moments in N·m)

Question	Answer	Ref.
Mass and centre of gravity of the boat calculated for conditions LC1 and LC2? YES/NO		B.3.2.2
Curves of righting moments calculated according to Annex D? YES/NO		B.3.2.3
Crew heeling moment curve calculated with 961 CL (B_C/2 – 0,2) cosϕ or where the crew area includes side decks less than 0,4 m wide with 480 CL B_C cosϕ? YES/NO		B.3.2.4

Test data:

Item	Symbol	Unit	LC1	LC2	Ref.
Maximum transverse distance between the outboard extremities of any part of the crew area	B_C	m			B.3.2.4 & B.3.1.7
Heel angle at the point of intersection between crew heeling moment curve and curve of righting moment	ϕ_C	degrees			
Maximum permitted heel angle	$\phi_{O(R)}$	degrees			B.3.2.5
Value of downflooding angle	ϕ_D	degrees			B.3.2.5
Value of minimum freeboard margin at ϕ_C	h_F	m			
Minimum required freeboard margin	$h_{F(R)}$	m			6.2.2 Table 4
Righting moment at ϕ_D		N·m			
Crew heeling moment at ϕ_D		N·m			

Requirements:

Question	Answer		Ref.
Is ϕ_C < $\phi_{O(R)}$? YES/NO			B.3.2.5
Is $h_F > h_{F(R)}$? YES/NO			B.3.2.5
Is max righting moment up to ϕ_D > crew heeling moment at ϕ_D? YES/NO			B.3.2.5
Offset load test passed, if all questions above are answered with 'Yes' PASS/FAIL			B.3.2.5

ISO 12217-1 CALCULATION WORKSHEET No. 6 RESISTANCE TO WAVES+WIND

NB: This sheet is to be completed for both minimum operating condition and loaded arrival condition.

Input data: Design categories A and B only

Item	Symbol	Unit	m_{LA}	m_{MO}	Ref.
Minimum operating mass	m_{MO}	kg			3.4.3
Loaded arrival mass	m_{LA}	kg			3.4.6
Displacement volume (= m_{MO} /1 025 or m_{LA}/1 025)	V_D	m^3			3.4.7
Windage area (of above water profile of boat)	A_{LV}	m^2			3.3.7
Windage area to be used (not to be < 0,55$L_H B_H$)	A'_{LV}	m^2			6.3.2
Length waterline	L_{WL}	m			3.3.2
Lever between centroids of above and below water areas	h	m			6.3.2
Downflooding angle	ϕ_D	degrees			3.2.2

Item	Symbol	Unit	Cat A	Cat B	Ref.
Calculation wind speed	v_W	m/s	28	21	3.5.1

ISO 12217-1 CALCULATION WORKSHEET No. 6 (*continued*)
RESISTANCE TO WAVES+WIND

NB: This sheet is to be completed for both minimum operating condition and loaded arrival condition.

Rolling in beam waves and wind:

Item	Symbol	Unit	m_{LA}	m_{MO}	Ref.
Second wind heel equilibrium angle		degrees			Fig. 6
Least value of ϕ_D, 50° or second wind heel equilibrium angle	ϕ_{A2}	degrees			Fig. 6
Wind heeling moment = 0,53 $A'_{LV}\, h\, v_W^2$ or = 0,30 $A'_{LV}\,(A'_{LV} / L_{WL} + T_M)\, v_W^2$	M_W	N·m			6.3.2
Assumed roll angle Category A = (25 + 20/V_D) Category B = (20 + 20/V_D)	ϕ_R	degrees			6.3.2
Area A_1 (see Fig. 6)	A_1	any			Fig. 6
Area A_2 (see Fig. 6)	A_2	any			Fig. 6
Ratio of A_2/A_1		—			6.3.2
Is ratio of A_2/A_1 greater than or equal to 1,0?		YES/NO			6.3.2

Resistance to waves:

Item	Symbol	Unit	m_{LA}	m_{MO}	Ref.
Least value of ϕ_D, ϕ_V or 50°		degrees			6.3.3
Heel angle when righting moment is maximum	ϕ_{GZmax}	degrees			6.3.3
If ϕ_{GZmax} is greater than or equal to 30°: Max. value of righting moment at 30°	RM_{30}	kN·m			6.3.3a)
Required value of righting moment		kN·m			6.3.3 a)
Is $RM_{30°}$ greater than or equal to required max. value?		PASS/FAIL			6.3.3 b)
Value of righting lever at 30º = $RM_{30}/(9{,}806m)$	GZ_{30}	m			3.5.10
Required value of righting lever at 30º		m	0,20		6.3.3 a)
Is $GZ_{30°}$ greater than or equal to required max. value?		PASS/FAIL			6.4.3 a)
If ϕ_{GZmax} is less than 30°: Max. value of righting moment	RM_{max}	kN·m			6.3.3 b)
Required value RM_{max} (A = 750/ϕ_{GZmax}, B = 210/ϕ_{GZmax})		kN·m			6.3.3 b)
Is RM_{max} greater than or equal to required max. value?		PASS/FAIL			6.3.3 b)
Max. value of righting lever = $RM_{max}/(9{,}806m)$	GZ_{max}	m			3.5.10
Required max. value of righting lever = 6/ϕ_{GZmax}		m			6.3.3 b)
Is GZ_{max} greater than or equal to required max value?		PASS/FAIL			6.3.3 b)

Design category given: NB: Boat must meet both recess limitations, have ratio of A_2/A_1 greater than or equal to 1,0, and also get PASS twice under resistance to waves.	

ISO 12217-1 CALCULATION WORKSHEET No. 7 HEEL DUE TO WIND ACTION

Design categories C and D only

NB: This sheet is to be completed for both minimum operating condition and loaded arrival condition.

Initial check:

Item	Symbol	Unit	Value at m_{MO}	Ref.
Windage area (NOT subject to minimum of 0,55 L_{WL} B_H)	A_{LV}	m^2		3.3.7
Length waterline	L_{WL}	m		3.3.2
Beam of hull	B_H	m		3.3.3
Ratio $A_{LV}/(L_{WL}\ B_H)$		—		
Is ratio $A_{LV}/(L_{WL}\ B_H)$ equal to or greater than 0,55?		YES/NO		6.4
If answer is NO, no further assessment is required.				

Calculation of wind heeling moment:

Item	Symbol	Unit	m_{LA}	m_{MO}	Ref.
Length waterline	L_{WL}	m			3.3.2
Draught at the mid-point of L_{WL}	T_M	m			6.3.2
Lever between centroids of above and below water areas	h	m			6.3.2
Calculation wind speed (17 m/s for Category C, 13 m/s for Category D)	v_W	m/s			3.5.1
Wind heeling moment = 0,53 $A_{LV}\ h\ v_W^2$ or = $0{,}30 A_{LV}(A_{LV}/L_{WL} + T_M)\ v_W^2$	M_W	N·m			6.3.2, 6.4.2

Angle of heel due to wind:

Item	Symbol	Unit	m_{LA}	m_{MO}	Ref.
FROM RIGHTING MOMENT CURVE: angle of heel due to wind	ϕ_W	degrees			6.4.3
OR ALTERNATIVELY: wind heeling moment M_W divided by 9,806		kg.m			
Angle of heel due to wind when moment above applied	ϕ_W	degrees			6.4.3
Maximum permitted angle of heel during offset load test (from Worksheet 3)	$\phi_{O(R)}$	degrees			6.2.3
Downflooding angle	ϕ_D	degrees			3.2.2
Maximum permitted heel due to wind = lesser of $0{,}7\phi_{O(R)}$ and $0{,}7\phi_D$		degrees			6.4.3
Is angle of heel due to wind less than permitted value?		YES/NO			6.4.3
Design category possible on wind heeling =					

ISO 12217-1 CALCULATION WORKSHEET No. 8 RECESS SIZE

NB: This sheet is to be completed for the loaded arrival condition.

Item	Symbol	Unit	Value Recess 1	Value Recess 2	Ref.
Angle of vanishing stability > 90°?		YES/NO			6.5.1a)
Depth recess < 3 % max. breadth of the recess over >35 % of periphery?		YES/NO			6.5.1b)
Bulwark height < B_H /8 and has ≥ 5% drainage area in the lowest 25 %?		YES/NO			6.5.1c)
Drainage area per side (m²) divided by recess volume (m³)					6.5.1d)
Height position of drainage area (lowest 25 % / lowest 50 % / full depth)					6.5.1d)
Drainage area meets requirements 1) and 2)?		YES/NO			6.5.1d)
Recess exempt from size limit?		YES/NO			6.5.1
SIMPLIFIED METHOD: Use 1), 2) or 3) below.			**Zone 1**	**Zone 2**	
Requirement: from results below, design category possible =					6.5.2.1
Average freeboard to loaded waterline at aft end of recess	F_A	m			6.5.2.1
Average freeboard to loaded waterline at sides of recess	F_S	m			6.5.2.1
Average freeboard to loaded waterline at forward end of recess	F_F	m			6.5.2.1
Average freeboard to recess periphery = $(F_A + 2F_S + F_F) / 4$	F_R	m			6.5.2.1
Category A permitted percentage loss in metacentric height (GM_T) = 250 F_R / L_H					6.5.2.1
Category B permitted percentage loss in metacentric height (GM_T) = 550 F_R / L_H					6.5.2.1
Category C permitted percentage loss in metacentric height (GM_T) = 1 200 F_R / L_H					6.5.2.1
1) Loss of GM_T used?		YES/NO			6.5.2.2
second moment of area of free-surface of recess	SMA_{RECESS}	m⁴			6.5.2.2
metacentric height of boat at m_{LA}	GM_T	m			6.5.2.2
Calculated percentage loss in metacentric height (GM_T) = $\frac{102\,500 \times SMA_{RECESS}}{m_{LA} \times GM_T}$					6.5.2.2
2) Second moment of areas used?		YES/NO			6.5.2.3
second moment of area of free-surface of recess	SMA_{RECESS}	m⁴			6.5.2.3
second moment of area of waterplane of boat at m_{LA}	SMA_{WP}	m⁴			6.5.2.3
Calculated percentage loss in metacentric height (GM_T) = $\left(\frac{220 \times SMA_{RECESS}}{SMA_{WP}}\right)$					6.5.2.3
3) Recess dimensions used?		YES/NO			6.5.2.4
maximum length of recess at the retention level (see 3.5.11)	l	m			6.5.2.4
maximum breadth of recess at the retention level (see 3.5.11)	b	m			6.5.2.4
Calculated percentage loss in metacentric height (GM_T) = $240\left(\frac{l \times b^3}{L_H \times B_H^3}\right)^{0,7}$					6.5.2.4
DIRECT CALCULATION METHOD used?		YES/NO			6.5.3
percentage full of water = 60 – 240 F/L_H					6.5.3a)
wind heeling moment for intended design category	M_W	N·m			6.5.3b)
crew heeling moment at ϕ_{GZmax}		N·m			6.5.3c)
maximum swamped righting moment up to least of ϕ_D ϕ_V or 50°		N·m			6.5.3d)
required margin of righting moment over heeling moment		N·m			6.5.3d)
actual margin of righting moment over heeling moment		N·m			6.5.3d)
design category possible					6.5.3d)
Design category achieved					

ISO 12217-1 CALCULATION WORKSHEET No. 9 HABITABLE MULTIHULLS & MOTOR SAILERS

HABITABLE MULTIHULLS

NB: Boats complying with the other requirements of this standard for design categories A, B or D are not considered to be vulnerable to inversion.

Boats of design category C:

Item	Symbol	Unit	Value	Ref.
beam of hull	B_H	m		3.3.3
volume of displacement in the minimum operating condition	V_D	m³		3.4.7
cube root of above	$V_D^{1/3}$	m		
height of the centroid of A_{LV} the above m_{MO} waterline	h_C	m		6.6.3
Boat is vulnerable if: when $V_D^{1/3} > 2,6$ $h_C / B_H >$			0,572	6.6.3
when $V_D^{1/3} \leq 2,6$ $h_C / B_H > 0,22\ V_D^{1/3}$ =				6.6.3
actual value of h_C / B_H =				
IS BOAT VULNERABLE TO INVERSION IN CATEGORY C?		YES/NO		6.6.3
If YES, boat must comply with ISO 12217-2:2013, 7.12 and 7.13 (use relevant ISO 12217-2 worksheet)				6.6.1
Boat complies with ISO 12217-2:2013, 7.12 buoyancy when inverted?		YES/NO		6.6.1 a)
Boat complies with ISO 12217-2:2013, 7.13 escape after inversion?		YES/NO		6.6.1 b)

MOTOR SAILERS

NB: Only applicable to non-sailing boats with sails of design categories A or B

Item	Symbol	Unit	Value		Ref.
			Cat. A	Cat. B	
windage area plus the actual profile area, including overlaps, of the largest sail plan suitable for windward sailing in >10 kt winds	A_{max}	m²			6.7.2
vertical distance between centre of A_{max} and underwater area	h	m			6.7.2
wind speed = 18 m/s for category A, and 14 m/s for category B	v_W	m/s			6.7.2
heeling moment due to wind = 0,53 $A_{max}\ h\ v_W^2$	M_W	N·m			6.7.2
maximum righting moment of the boat at m_{LA} up to ϕ_{DA}	RM_{max}	N·m			3.5.11
Is RM_{max} greater than $2 \cdot M_W$?		YES/NO			6.7.2
Design category given					

ISO 12217-1 CALCULATION WORKSHEET No. 10 FLOTATION TEST

Annexes E and F assumed Crew Limit (CL) = ……………

Preparation:

Item	Unit	Response	Ref.
Mass equal to 25 % of dry stores and equipment added?	YES/NO		F.2 a)
Inboard or outboard engine fitted?			
If inboard fitted, correct engine replacement mass fitted?	YES/NO		F.2 d)
Assumed outboard engine power	kW		F.2 c)
Mass fitted to represent outboard engine, controls and battery	kg		Tables F.1 and F.2
Portable fuel tanks removed and/or fixed tanks are filled?	YES/NO		F.2 f)
Cockpit drains open and drain plugs are fitted?	YES/NO		F.2 g)
Void compartments which are not air tanks are opened?	YES/NO		F.2 i)
Number of integral air tanks required to be opened			Table F.3
Type of test weights used: lead, 65/35 brass, steel, cast iron, aluminium			F.3.2
Material factor d			Table F.4

Swamped stability test:

Item	Unit	Response	Ref.
Dry mass of test weights = 6dCL but ≥ 15d	kg		Table F.6
Test weight hung from gunwale each of four positions in turn?	YES/NO		F.3.1
5 min after swamping, boat heels less than 45°?	PASS/FAIL		F.3.4 + F.3.5

Swamped buoyancy tests:

Item	Unit	Response	Ref.
Load test:			F.4
Design category assessed			
Dry mass of test weights used	kg		Table F.5
5 min after swamping, boat floats approximately level with more than 2/3 of periphery above water?	PASS/FAIL		F.4.3

Flotation material and elements:

Item		Response	Ref.
All flotation elements comply with all the requirements?	PASS/FAIL		Table G.1

Design category given: NB: boat must obtain PASS three times in above tables

ISO 12217-1 CALCULATION WORKSHEET No. 11 DETECTION + REMOVAL OF WATER

Item	Response	Ref.
The internal arrangement facilitates the drainage of water to bilge suction point(s), to a location from which it can be bailed rapidly, or directly overboard? YES/NO		6.9.1
Is boat provided with means of removing water from the bilges in accordance with ISO 15083? YES/NO		6.9.2
Table 2 option used for assessment:		6.9.3
Can water in boat be detected from helm position? YES/NO		6.9.3
Method(s) used: direct visual inspection		6.9.3
transparent inspection panels		6.9.3
bilge alarms		6.9.3
indication of the operation of automatic bilge pumps		6.9.3
other means (specify):		6.9.3

ISO 12217-1 CALCULATION WORKSHEET No. 12 SUMMARY

Design description:				
Design category intended:	**Crew limit:**		**Date:**	
Sheet	**Item**	**Symbol**	**Unit**	**Value**
1	**Length of hull:** (as in ISO 8666)	L_H	m	
	Length waterline in loaded arrival condition:	L_{WL}	m	
	Mass:			
	Empty craft mass	m_{EC}	kg	
	Maximum load	m_L	kg	
	Light craft condition mass	m_{LC}	kg	
	Maximum load condition mass = m_{LC} + m_L	m_{LDC}	kg	
	Loaded arrival condition mass	m_{LA}	kg	
	Minimum operating condition mass	m_{MO}	kg	
	Is boat sail or non-sail?		SAIL/NON-SAIL	
2	**Option selected:**			
3	**Downflooding openings:** Are all requirements met?		YES/NO	

Sheet	**Item**	**Unit**	**Requ'd**	**Actual** m_{MO}	**Actual** m_{LA}	**Pass/ Fail**
3	**Downflooding angle:** (Categories A and B only)	deg	≥			
3 & 4	**Downflooding height:** Worksheet used:					
	basic requirement	m	≥			
	reduced height for small openings (sheet 4 only)	m	≥			
	reduced height at outboard (options 3 + 4 only)	m	≥			
	increased height at bow (options 3, 4, 6 only)	m	≥			
5	**Offset load test:**					
	testing for least stability: maximum heel angle	degrees	<			
	testing for least freeboard: heeled freeboard margin	mm	≥			
	maximum crew limit for stability					
	maximum crew limit for freeboard					
6	**Resistance to waves+wind:** (options 1, 3) at m_{LA} and at m_{MO}					
	Rolling in beam waves and wind: ratio A_2/A_1	—	≥ 1,0			
	Resistance to waves: value of ϕ_{GZmax}	degrees	—			
	value of RM_{30} or RM_{max}	N·m	>			
	value of GZ_{30} or GZ_{max}	m	≥			
7	**Heel due to wind:** (options 2, 4, 5, 6) at m_{LA} and at m_{MO}					
	Is ratio $A_{LV}/(L_{WL}\ B_H) \leq 0{,}55$?		YES /NO			
	If YES: at m_{LA}: heel angle due to wind	degrees	<			
	if required at m_{MO}: heel angle due to wind	degrees	<			
8	**Recess size:** (options 1 and 2 except category D)					
	Simplified method: max reduction in GM_T	%	≤			
	Direct calculation: margin righting over heeling mom't	N·m	≥			

ISO 12217-1 CALCULATION WORKSHEET No. 12 (*continued*) SUMMARY

Sheet	Item		Pass/Fail
9	**Habitable multihulls:** Is Category C boat vulnerable to inversion?	YES/NO	
	Complies with ISO 12217-2:2013, 7.12 for inverted buoyancy?	PASS/FAIL	
	Complies with ISO 12217-2:2013, 7.13 for means of escape?	PASS/FAIL	
9	**Motor sailers**		
	Complies with requirement for excess of RM_{max} over M_W?	PASS/FAIL	
10	**Flotation test:** (options 3 and 4 only) All preparations completed?	YES/NO	
	Swamped stability: 5 min after swamping, does boat heel less than 45°?		
	Load test: 5 min after swamping, does boat float level with 2/3 periphery showing?		
	Flotation elements: do all elements comply with all the requirements?		
11	**Detection & removal of water:** are all requirements satisfied?	YES/NO	
NB: Boat must pass all requirements applicable to selected option to be given intended design category.			
Design category given:	Assessed by:		

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[2] *Principles of Naval Architecture*, published by the Society of Naval Architects and Marine Engineers in the USA

[3] ASTM F1321-92, *Guide for Conducting a Stability Test (Lightweight Survey and Inclining Experiment) to Determine the Lightship Displacement and Centres of Gravity of a Vessel*

[4] IMO Resolution MSC.81(70), *Revised Recommendation on Testing of Life-Saving Appliances*

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