INTERNATIONAL STANDARD

ISO 11812

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Small craft — Watertight cockpits and quick-draining cockpits

Petits navires — Cockpits étanches et cockpits rapidement autovideurs

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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 3.

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

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

International Standard ISO 11812 was prepared by Technical Committee ISO/TC 188, *Small craft*.

Annexes B, C, D and E form a normative part of this International Standard.

Annex A is for information only.

Introduction

The compliance to this International Standard may not be required to show that a boat fulfils the essential safety requirements of the Directive 94/25/EC, but it may be required by ISO 12217.

Small craft — Watertight cockpits and quick-draining cockpits

1 Scope

This International Standard specifies requirements for cockpits and recesses to be designated either as “watertight” or as “quick-draining” on small craft of hull length up to 24 m.

It does not set requirements for the size and shape of a cockpit or recess, nor when or where it shall be used. It only considers draining by gravity, and not by pumping or other methods.

NOTE 1 The term “quick-draining cockpit” has been chosen to differentiate from the common understanding of “self-draining cockpit” where water may be drained overboard in certain conditions, but without specified draining speed, height of bottom or sill, etc.

NOTE 2 Examples of single-plane cockpit bottoms are given in informative annex A.

2 Normative references

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

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

ISO 9093-1:1994, *Small craft — Seacocks and through-hull fittings — Part 1: Metallic*

ISO 9093-2:—[1)], *Small craft — Seacocks and through-hull fittings — Part 2: Non-metallic*

ISO 12216:—[1)], *Small craft — Windows, portlights, hatches, deadlights and doors — Strength and tightness requirements*

ISO 12217-1:—[1)], *Small craft — Stability and buoyancy assessment and categorization — Part 1: Non-sailing boats of hull length greater than or equal to 6 m*

ISO 12217-2:—[1)], *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:—[1)], *Small craft — Stability and buoyancy assessment and categorization — Part 3: Boats of hull length less than 6 m*

1) To be published.

3 Terms and definitions

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

3.1
design categories
description of the sea and wind conditions for which a boat is assessed to be suitable

NOTE The following design categories apply:

— **A: Ocean:** Designed for extended voyages where conditions may exceed wind force 8 (Beaufort scale) and significant wave heights of 4 m and above, and vessels largely self-sufficient; but excluding abnormal conditions such as hurricanes.

— **B: Offshore:** Designed for offshore voyages where conditions up to and including wind force 8 and significant wave heights up to and including 4 m may be experienced;

— **C: Inshore:** Designed for voyages in coastal waters, large bays, estuaries, lakes and rivers where conditions up to and including wind force 6 and significant wave heights up to and including 2 m may be experienced;

— **D: Sheltered waters:** Designed for voyages in close coastal waters, small bays, lakes, rivers and canals where conditions up to and including wind force 4 and maximum wave heights up to and including 0,3 m may be experienced.

3.2
length of hull
L_{H}
length of the hull according to ISO 8666

NOTE Length of hull is expressed in metres.

3.3
maximum beam
B_{max}
overall beam of monohull or multihull craft according to ISO 8666

NOTE Maximum beam is expressed in metres.

3.4
waterline
WL
waterline in the fully loaded ready-for-use condition

3.5
freeboard amidships
F_{M}
freeboard at mid-waterline in fully loaded ready-for-use condition according to ISO 8666

3.6
sailing boat
boat designed to use sails as its primary means of propulsion, as defined in ISO 12217-2

3.7
non-sailing boat
boat not designed to use sails as primary means of propulsion, as defined in ISO 12217-1

3.8
cockpit and recess
any area that may retain water, however briefly, due to rain, waves, boat heeling, etc.

NOTE Cockpits are normally designed for accommodation of people but, for the purpose of this International Standard, the term "cockpit" will be used either for a proper cockpit or for any recess. This means that

— bulwarks may create a large cockpit,

— open boats may effectively comprise a cockpit which includes nearly all the boat,

— cockpit(s) may be situated anywhere in the boat, and

— a cockpit may open aft to the sea.

3.9
watertight cockpit or recess
cockpit or recess which satisfies the requirements of this International Standard for watertightness and sill heights, but not those for drainage

3.10
quick-draining cockpit or recess
cockpit with characteristics and draining capacity which fulfil all the requirements of this International Standard for one or several design categories

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

3.11
cockpit sole
essentially horizontal surface(s) of the cockpit on which people normally stand

3.12
cockpit bottom
lowest surface of the cockpit sole where water collects before being drained

NOTE 1 Devices raising the standing level(s) from the rigid part of the cockpit sole, e.g. grating, stands, bridge decks, are not considered as part of the cockpit bottom.

NOTE 2 The cockpit bottom is considered to comprise only one plane. A cockpit bottom with several levels is considered according to annex B.

3.13
bridge deck
area just outside the companionway opening and above the cockpit bottom, onto which people normally step before entering the accommodation

3.14
closing appliance
device used to cover an opening in the cockpit, hull or superstructures

EXAMPLE Hatch, window, door, engine cover, etc.

3.15
cockpit water-retention height
h_C
height of the water contained in the cockpit measured between the cockpit bottom and the point of overflow outboard, the boat being upright, at rest and fully loaded

NOTE 1 This height corresponds to the lowest point where the overflow area, expressed in square metres, is $> 0{,}005\ L_H\ B_{max}$, and is usually the lowest point of the cockpit coaming.

NOTE 2 For assessing h_C, every closing appliance, including the companionway door(s) is assumed to be closed.

3.16
cockpit bottom height
H_B
height of the cockpit bottom above the waterline, the boat being upright, at rest and fully loaded

NOTE For a single-plane cockpit bottom, H_B is measured at the centre of surface of this plane. For a multi-plane bottom, H_B is measured according to annex B.

3.17
minimum cockpit bottom height
$H_{B,min}$
minimum value of H_B required by this International Standard

3.18
drain
outlet of the cockpit enabling any water contained to be discharged outboard by gravity

NOTE A drain can be

— a pipe discharging overboard above or below the waterline,

— a part of the cockpit allowing direct discharge overboard,

— scuppers and freeing port,

— etc.

3.19
companionway opening
opening giving way to accommodation

NOTE There may be several companionway openings.

3.20
companionway door
door or closing appliance intended to close a companionway opening

3.21
washboards
closing appliance for companionway opening made of several mobile boards that, when closed, are stacked one on top of each other

NOTE 1 This is a very frequent device on sailing monohulls.

NOTE 2 Boards are added as the weather worsens to constitute a higher sill.

3.22
sill
barrier above which water in the cockpit may enter companionway openings and downflood the boat

NOTE The lids to cockpit lockers or any opening other than the companionway opening, and leading into non-quick-draining parts of the boat are not considered to be sills if the closing appliance covering them fulfils the watertightness requirements of clause 9.

3.23
fixed sill
sill being a fixed, integral and permanent part of the cockpit

3.24
semi-fixed sill
any closing appliance movable but permanently attached to the boat which, when in place, constitutes a sill higher than the fixed sill

EXAMPLE Sliding or hinged doors, hatches, sliding sills, but excluding washboards.

NOTE A lanyard is not regarded as a permanent attachment.

3.25
sill height
h_{s}
height of sill, either the top of a fixed sill, or of the mobile part, when closed, for a semi-fixed sill

3.26
minimum sill height
$h_{\mathrm{s,min}}$
minimum value of sill height required by this International Standard

3.27
cockpit volume
V_{C}
volume, in cubic metres, of water that can be instantaneously contained in the cockpit before discharge, which is the volume below h_{C}

3.28
cockpit volume coefficient
k_{C}
ratio between the cockpit volume and the reserve buoyancy

$$k_{\mathrm{C}} = \frac{V_{\mathrm{C}}}{L_{\mathrm{H}} B_{\mathrm{max}} F_{\mathrm{M}}}$$

3.29
degree of watertightness
ability of a closing appliance, fitting or surface, to resist ingress of water according to the conditions of protection from water

NOTE The degreee of water tightness 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.

4 Symbols

Table 1 summarizes the main symbols used in this International Standard.

Table 1 — Summary of symbols

Symbol	Unit	Meaning	Subclause or annex concerned
B_{max}	m	Maximum beam	3.3, 3.28
C_1	—	Draining-time reduction coefficient	Annex C
C_2	—	Loss coefficient for discharge above the waterline	Annex C
C_3	—	Loss coefficient for discharge below the waterline	Annex C
d	mm	Drain diameter in millimetres	7.8, annexes B,C,D
D	m	Drain diameter in metres	Annex D
F_M	m	Freeboard amidships	3.5, 3.28
h_C	m	Cockpit water-retention height	3.15, 7.2, 8.1, 9.1, annexes A, B, C ,D
H_B	m	Cockpit bottom height above the waterline	3.16, 6.1, annex B
$H_{B,min}$	m	Minimum cockpit bottom height above the waterline	3.17, 6.1, 7.6, annex B
h_S	m	Sill height	3.25, 8.2, 9.2, annex B
$h_{S,min}$	m	Required minimum sill height	3.26, 8.2, 9.2, annex B
k_C	—	Cockpit volume coefficient	3.28, 7.2
L_H	m	Length of hull	3.2, 3.28
t_{max}	min	Maximum allowable draining time	7.2, 7.8, annexes B,C,D
t_{ref}	min	Reference draining time = t_{max}/V_C	7.8, annexes B, C
V_C	m^3	Cockpit volume	3.27, 3.28, 7.2
NOTE Heights measured above the cockpit bottom have symbols beginning with h, whereas heights measured above the waterline have symbols beginning with H.			

5 General requirements

5.1 Loading and measurement conditions

The loading conditions for the subclauses 5.2 to 5.4 are “fully loaded ready-for-use” as defined in ISO 8666. In some cases, the mass of water contained in specific volumes shall be added to this loading (see 6.2.1 and 6.2.2).

The measurement or calculations shall be made with the boat upright and at rest in smooth water.

NOTE This loading condition is surpassed and maybe the trim altered when the cockpit is in its draining period, i.e. when partially or totally filled with water.

5.2 Requirements for “watertight” cockpits and recesses

A “watertight” cockpit or recess shall

— have its sills in accordance with clause 8, and

— show a degree of watertightness in accordance with clause 9.

5.3 Requirements for "quick draining" cockpits and recesses

A "quick-draining" cockpit or recess shall

— have its bottom height H_B above the the waterline in accordance with clause 6;

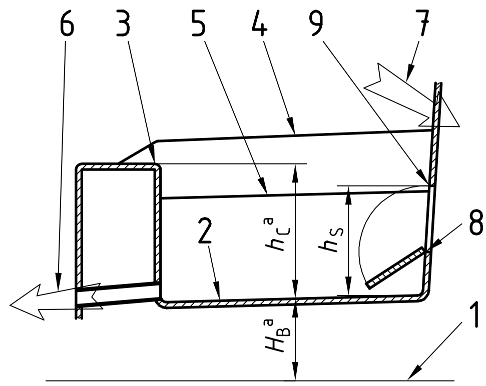
— have its draining devices in accordance with clause 7;

— have its sills in accordance with clause 8;

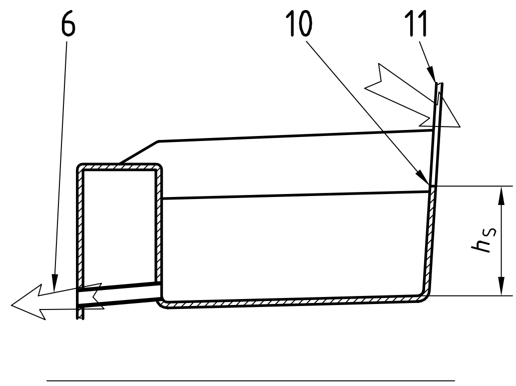
— show a degree of watertightness in accordance with clause 9.

For simplicity, the main part of this International Standard considers cockpits having only one bottom level. Cockpits having several bottom levels shall be analysed according to annex B.

Figure 1 gives schematically the principal heights used in this International Standard for a one-level bottom cockpit.



a) Case of a semi-fixed sill



b) Case of a fixed sill

Key

1	Waterline	7	Access companionway
2	Cockpit bottom	8	Top of the fixed part
3	Overflow point	9	Top of the mobile part
4	Coamings Chambers and compartments	10	Top of fixed sill
5	Seats	11	Companionway closed by washboards
6	Drain		

a H_B and h_C measured at the centre of the cockpit bottom

Figure 1 — Schematic longitudinal section of a cockpit

5.4 Closing appliances

Closing appliances fitted in watertight cockpits and quick-draining cockpits, and giving access to the interior of the boat, shall fulfil the requirements of ISO 12216 and of clause 9.

6 Requirements for quick-draining cockpit bottom

6.1 Minimum cockpit bottom height, $H_{B,min}$

The minimum cockpit bottom height, $H_{B,min}$, above the the waterline shall be according to Table 2.

Table 2 — Minimum height, $H_{B,min}$, of the cockpit bottom

Dimensions in metres

Design category	Height, $H_{B,min}$
A	0,15
B	0,1
C	0,075
D	0,05
NOTE Greater heights than these minimum values may be required to fulfil the maximum acceptable draining time according to 7.2	

6.2 Exception to 6.1 for recesses or lockers

6.2.1 Exception up to 10 % of cockpit bottom area

Surfaces up to a total 10 % of the horizontal projection of the cockpit bottom are not required to comply with 6.1. Among these surfaces, those containing water after the cockpit has drained will be considered full of water when assessing the fully loaded condition.

6.2.2 Lockers in the cockpit bottom

Lockers placed in the cockpit bottom

- which are intended for the storage of liferafts, ice, fish, baits, etc., and
- which are watertight towards the interior of the boat, and
- whose closing appliances do not fulfil all the requirements of 5.3,

are not regarded as part of the cockpit and are not required to comply with clause 9. They shall be considered full of water when assessing the fully loaded condition.

If fulfilling the requirements of 5.3 and clause 9, these lockers need not be considered full of water, but only filled with the maximum loading corresponding to the “fully loaded” condition.

7 Requirements for drainage of quick-draining cockpits

7.1 Cockpit drainage

7.1.1 General

Draining shall only be by gravity.

7.1.2 When the boat is upright

When the boat is upright, at least 98 % of the cockpit volume shall drain, excluding any recess in accordance with the exceptions of 6.2.

7.1.3 When the boat is heeled

The requirements in 7.1.3.1 and 7.1.3.2 shall be fulfilled when the boat is heeled to both port and starboard.

7.1.3.1 Sailing monohulls

On sailing monohulls, drainage shall be provided for at least 90 % of V_C at the lesser heel angle of

— 30° heel, or

— when the deck at side begins to touch the water.

7.1.3.2 Non-sailing boats and multihulls

On non-sailing boats and multihulls, drainage shall be provided for at least 90 % of V_C at 10° heel.

7.2 Draining time

The draining time is the time needed to drain the cockpit from the full height of water, h_C, down to a remainder of 0,1 m above cockpit bottom.

The draining time shall be measured or calculated with every appliance closed.

NOTE It is considered that a large cockpit volume relative to the boat's reserve buoyancy requires a correspondingly small draining time, as a prolonged time with the cockpit full of water would expose the boat to great hazard.

If the draining section, expressed in square metres, is greater than or equal to 0,05 V_C, it is considered large enough to fulfil the requirements and does not require a draining time assessment.

For other drain configurations, the draining time shall be assessed, and shall not be greater than t_{max} given by the formulae in Table 3 or by the curves in Figure 2.

Table 3 — Maximum acceptable draining time, t_{max}

Time in minutes

Design category	t_{max}
A	$0,3/k_C$ but not greater than 5
B	$0,45/k_C$ but not greater than 5
C	$0,6/k_C$ but not greater than 5
D	$0,9/k_C$ but not greater than 5

The cockpit volume, V_C, shall be measured from the cockpit bottom up to the top of h_C, with the eventual exception of 6.2, assuming that all closing appliances and drains are closed.

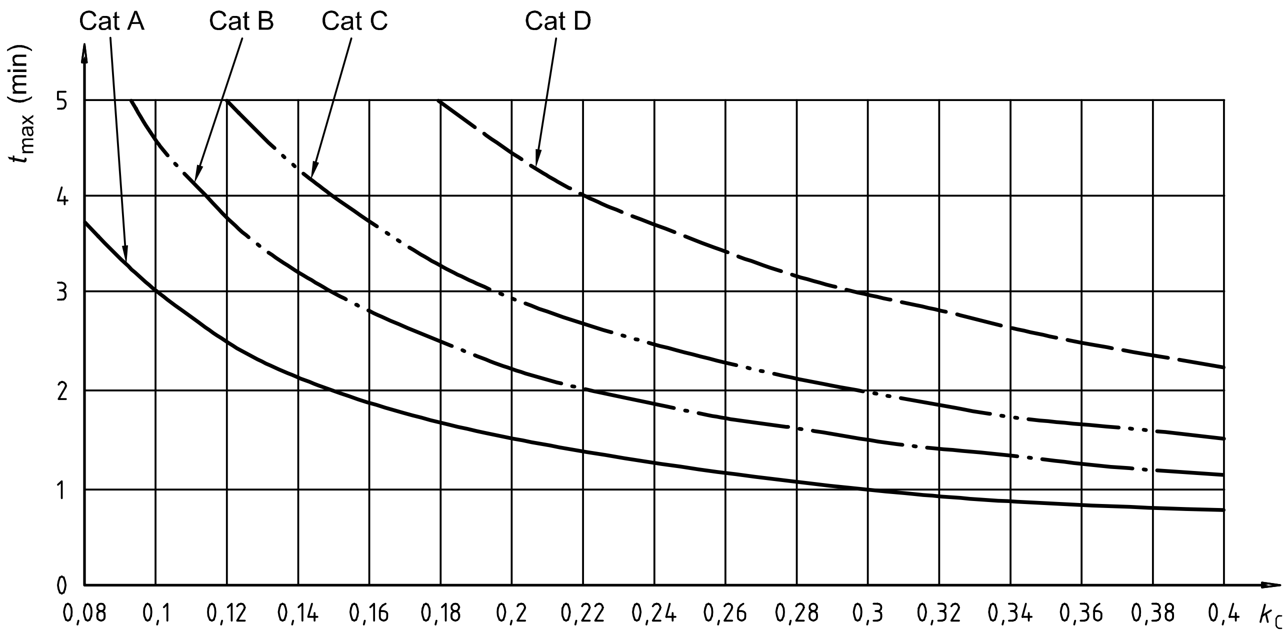


Figure 2 — Maximum acceptable draining time t_{max} according to k_C and design category

7.3 Number of drains

A quick-draining cockpit shall have at least two drains, one port and one starboard, unless one opening enables drainage when the boat is heeled to both port and starboard, as required in 7.1.

7.4 Minimum drain dimensions

7.4.1 Internal dimensions of the drain

Drains with a circular cross section shall have a diameter of at least 25 mm. Drains with other cross-sectional shapes shall have a cross-sectional area of at least 500 mm^2 and a minimum dimension of 20 mm.

NOTE The purpose of this subclause is to avoid taking into account drains that could be easily clogged by loose objects or ropes.

7.4.2 Eventual protective grids

If the drains are equipped with systems preventing loose objects from falling into the draining system, one shall be aware that a grid of small holes is more prone to be clogged than the drain itself.

If the minimum passage dimension inside any part of these devices has at least a section of 125 mm^2 (or a diameter of 12 mm), and the total entry cross-section is at least 1,5 times the cross-section of the drain, Table 4 may be used for calculation of the draining time.

If the above conditions are not met, the head losses from the protection grid shall be considered. See normative annex D.

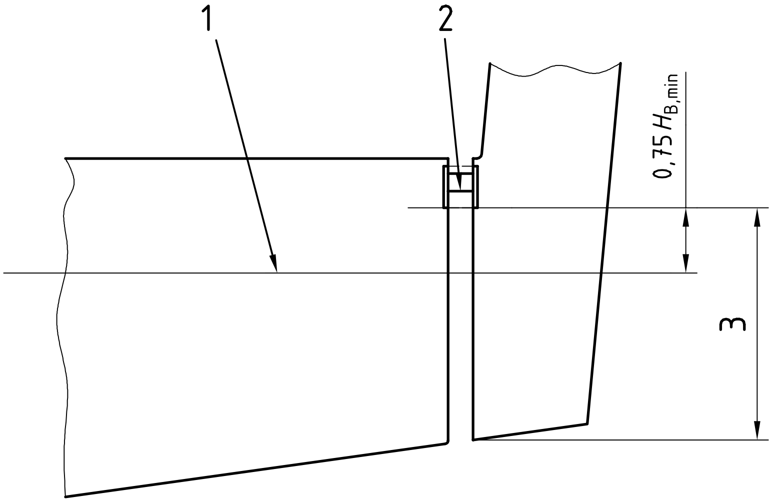
7.5 Centreboard housings and other types of drain

Centreboard housings and other types of aperture may be used as drains if they are designed for this purpose.

7.6 Drain fitting

The drain outlet running through the hull shall either be located above the waterline or, if below the waterline, be fitted with seacocks (see 7.7), unless the drain outlet is an integral part of the hull extending from the outlet up to at least 0,75 $H_{B,min}$ above the waterline.

Figure 3 shows a drain outlet integral with the hull.



Key

1 Waterline

2 Top of integral penetration above 0,75 $H_{B,min}$: no seacock required

3 In this area, the drain is integral with the hull shell

Figure 3 — Drain outlet as an integral part of the hull

7.7 Drain piping design and construction

The scantling and design of drains shall take into account all the loads to which they may be subjected.

Drain piping shall be protected against damage from loose objects stowed in the boat and against being kicked or stepped on.

Drain piping shall not trap water and shall only be used for cockpit drainage. This requirement does not apply to drains fitted in centreboard housing or outboard wells and trunks.

Seacocks, through-hull fittings, and associated components shall comply with the requirements of ISO 9093-1 or ISO 9093-2.

7.8 Draining time assessment

7.8.1 General

The draining time shall be determined either by measurement of the actual draining time, or by calculation.

7.8.2 Measurement of the draining time

The boat shall be placed near the fully loaded displacement and corresponding design trim.

The cockpit is filled with water up to h_C, and the draining time to empty the cockpit between h_C and 0,1 m of water remaining in the cockpit is measured. This latter height shall be measured above the centre of the bottom surface of the cokpit.

NOTE It may be useful to indicate the point located 0,1 m above the centre of the cockpit bottom with a tape mark.

7.8.3 Calculation of the draining time

A quick and approximate method of calculating the draining time calculation is given in 7.8.4. Simplifications in this method may lead to small differences between measured and calculated draining time, but both methods are considered valid.

More thorough methods of calculation are specified in annex C.

If the arrangement of cockpit and drains does not correspond to the cases of 7.8.4 or the methods of annex C, the calculation method used shall be based on a practical test on a similar arrangement.

7.8.4 Quick method of calculation for cockpit fitted with two drains

7.8.4.1 Step 1: Determination of the required maximum draining time t_{max}

Determine t_{max} using $k_C = V_C/(L_H\ B_{max}\ F_{mean})$, i.e. the cockpit volume coefficient in accordance with 7.2.

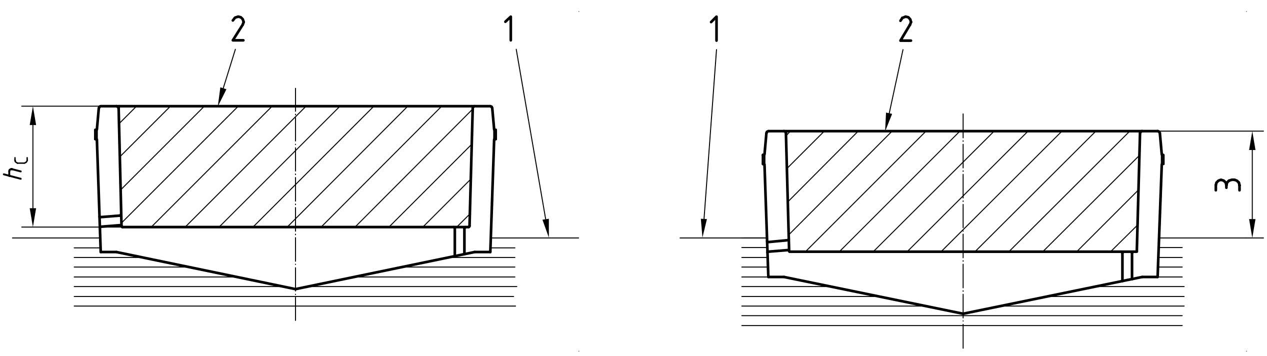
7.8.4.2 Step 2: Determination of the reference draining time, t_{ref}

Calculate $t_{ref} = t_{max}/V_C$ which is the reference draining time (without head loss) for a set of two drains.

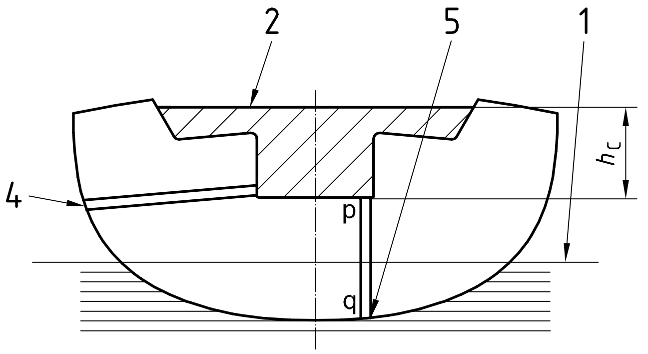
7.8.4.3 Step 3: Determine whether the drain outlet is above or below the waterline

Determine whether the drain outlet is above or below the waterline when the cockpit is full. If the drain outlet is above the waterline when the cockpit is empty and below it when the cockpit is full, one shall either conservatively consider that the drain is always below the waterline, or make the calculation in both cases and calculate the final time by interpolation.

Figure 4 shows some drain arrangements, but other arrangements may be used.



a) Cockpit bottom above the waterline **b) Cockpit bottom below the waterline**



c) Drain above or below the waterline

Key

1 Waterline

2 Level of water overflow

3 Height above the waterline

4 Discharge above the waterline

5 Discharge below the waterline

Figure 4 — Examples of some drain arrangements

NOTE 1 According to 6.1, the cockpit bottom may be above the waterline when the cockpit is empty and below it with a full cockpit.

In Figure 4c) an attempt shall not be made to apply the Bernouilli equation between water level in the cockpit and point q (drain outlet) instead of point p (drain inlet). A bigger water flow would then occur but, as water is uncompressible, the flow in the drain must be the same in p and q. The flow speed at the inlet therefore governs the flow speed in the whole drain.

7.8.4.4 Step 4: Determination of the required drain diameter

Table 4 gives the approximate draining time for six cases: drain above or below the waterline, no elbow or two elbows, and freeing port with and without a flap.

Enter the line corresponding approximately to the cockpit configuration and choose the drain diameter giving a draining time t_{ref} corresponding to the requirements. Interpolations may be used.

Table 4 — Drain diameter as a function of t_{ref} and typical drain arrangement

Typical drain arrangement	Values of t_{ref} (min)																		
Drain outlet above W_L, no elbow	8,8	5,8	4,1	3,0	2,3	1,8	1,5	1,2	1,0	0,9	0,8	0,7	0,5	0,4	0,3	0,3	0,2	0,2	0,2
Drain outlet above W_L, two elbows	10,0	6,7	4,7	3,5	2,7	2,2	1,8	1,5	1,3	1,1	0,9	0,8	0,6	0,5	0,4	0,4	0,3	0,3	0,2
Drain outlet below W_L, no elbow	10,8	7,2	5,1	3,9	3,0	2,4	2,0	1,6	1,4	1,2	1,0	0,9	0,7	0,6	0,5	0,4	0,3	0,3	0,2
Drain outlet below W_L, two elbows	11,8	7,9	5,7	4,3	3,3	2,7	2,2	1,8	1,5	1,3	1,2	1,0	0,8	0,6	0,5	0,4	0,4	0,3	0,3
Freeing port above W_L, no flap	10,1	7,0	5,2	3,9	3,1	2,5	2,1	1,8	1,5	1,3	1,1	1,0	0,8	0,6	0,5	0,4	0,4	0,3	0,3
Freeing port above W_L, with flap	15,2	10,5	7,7	5,9	4,7	3,8	3,1	2,6	2,2	1,9	1,7	1,5	1,2	0,9	0,8	0,7	0,6	0,5	0,4
Drain diameter d (mm) two drains	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**

NOTE The time calculations given in Table 4 are for a draining time between a height of water h_C = 0,40 m to a remaining 0,10 m of water, with two drains, each one 1,2 m long and a coefficient of head loss at the entry K = 0,06 (see D.3). For different values of h_C, the draining time is smaller (multiplied by coefficient C_1 of Table C.1). The draining time for a freeing port fitted with flaps is considered as 150 % of the draining time without a flap, this assessment may be adjusted by a test.

For a non-circular drain section, the section area shall be the same as that of a circular drain.

8 Requirements for sills

8.1 Sill height for watertight cockpits

Watertight cockpits shall have no opening below the height h_C.

8.2 Sill height and other requirements for quick-draining cockpits

8.2.1 Sill-height measurement

When measuring the sill height, all closing appliances shall be considered to be closed, with the exception of companionway door(s). The sill height is the lowest height of the openings considered to be sills.

Any vertical bulkhead or partial bulkhead cut by a companionway aperture leading to the interior, and located close to a cockpit or on the deck shall fulfil all the requirements for sill height and watertightness of this clause 8 and clause 9.

The sill height shall be measured vertically from the cockpit bottom to the lowest point on the sill edge that allows ingress of water.

If the cockpit bottom is not horizontal, the sill height shall be measured to the closest point of the cockpit bottom.

Cockpits having more than one bottom level shall be assessed using informative annex A.

8.2.2 Requirements for sill height of quick draining cockpits

The required minimum sill height $h_{s,min}$ according to boat type and design category is given in Table 5.

The value of $h_{s,min}$ may be used in clause 9 or informative annex A when considering multi-level cockpits.

Table 5 — Minimum values $h_{s,min}$ for fixed sills and semi-fixed sills

Dimensions in metres

Design category	Sailing monohulls			Non-sailing boats and sailing multihulls		
	Fixed sill	Semi-fixed sill		Fixed sill	Semi-fixed sill	
	Top of sill $h_{s,min}$	Top of fixed part $h_{s,min}/2$	Top of mobile part $h_{s,min}$	Top of sill $h_{s,min}$	Top of fixed part $h_{s,min}/2$	Top of mobile part $h_{s,min}$
A	0,3	0,15	0,3	0,2	0,1	0,2
B	0,25	0,125	0,25	0,15	0,075	0,15
C	0,15	0,075	0,15	0,1	0,05	0,1
D	0,05	0,025	0,05	0,05	0,025	0,05
NOTE The above requirements may be raised by other International Standards, such as ISO 12217.						

8.2.3 Requirements for companionway doors and appliances above sill height

Above sill level, whether fixed or semi-fixed, appliances complying with ISO 12216 shall be used to close the openings, at least up to h_C.

EXAMPLE Doors, hatches, washboards.

8.2.4 Other requirements

Semi-fixed sills and washboards shall have a device maintaining them in place, when in use, which shall at least be operable from inside.

Semi-fixed sills and washboards shall meet the strength requirements of ISO 12216.

Semi-fixed sills shall only be detachable with the use of tools.

Provision shall be made for washboards to be stowed in a readily accessible specific location in the vicinity of the companionway.

NOTE "Readily accessible" means capable of being reached quickly and safely without the use of tools.

9 Watertightness requirements

9.1 Watertightness requirements of watertight cockpits

All surfaces of watertight cockpits up to h_C shall have a watertightness degree 1.

9.2 Watertightness requirements of quick-draining cockpits

9.2.1 Watertightness of the cockpit

All surfaces of quick-draining cockpits up to h_C shall have a watertightness degree 1.

The watertightness degrees of the closing appliances shall be as required by Table 6.

Table 6 — Required degree of watertightness of quick-draining-cockpit closing appliances

Location of the closing appliance in the cockpit	Degree of watertightness
Closing appliances on bottom and horizontal areas	2
Closing appliances on cockpit sides up to $h_{s,min}$	2
Closing appliances on cockpit sides between $h_{s,min}$ and 2 $h_{s,min}$[a]	3
Closing appliances on cockpit sides above 2 $h_{s,min}$[a]	4
NOTE 1 The above requirements may be increased in other International Standards, such as ISO 12217. NOTE 2 The above requirements only apply to appliances covering openings which give way towards the interior (non-quick-draining) part of the boat (see 6.2.2).	
[a] $h_{s,min}$ being measured from the nearest part of the cockpit bottom. Informative annex A explains how to consider the main examples of cockpit layout.	

Hatches and appliances located in the bottom or sides of the cockpit up to $h_{s,min}$ shall be fitted with seals and sills at least 12 mm high, or tested as installed to watertightness degree 2 according to annex E.

The above watertightness degrees, if appropriate, shall be tested according to annex E.

9.2.2 Permanently open ventilation openings

The lowest point of non-closable ventilation openings leading to water ingress in the interior shall be at least at a height $2h_{s,min}$ or 0,3 m, whichever is the greater, above the cockpit bottom, and shall be watertight to degree 4.

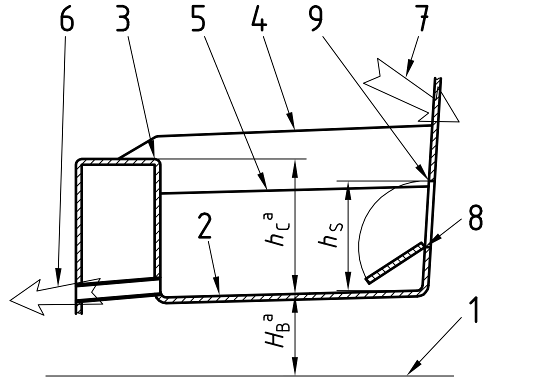
NOTE This requirement may be increased in other International Standards, such as ISO 12217.

10 Owner's manual — Documentation

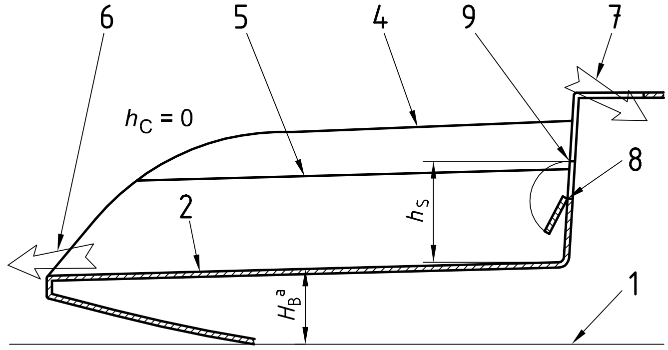
A cockpit may be documented "watertight" or "quick-draining" in the owner's manual and any other documentation only if it respectively fills the requirements of this International Standard for the advertised design category (categories) of the boat.

Annex A
(informative)

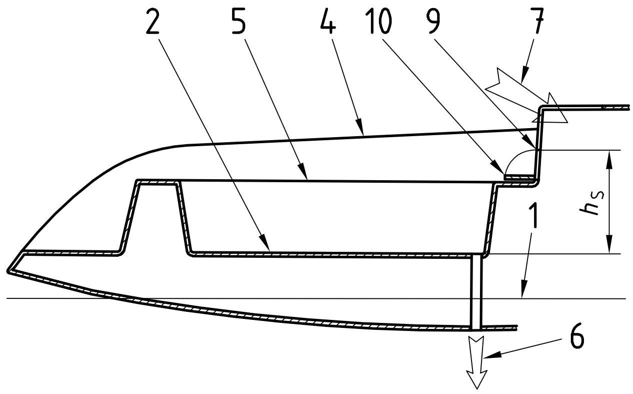
Examples of single-plane cockpit bottoms



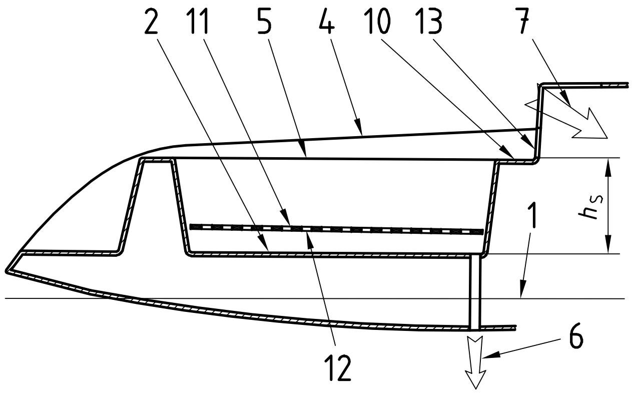
a) General layout with semi-fixed sill



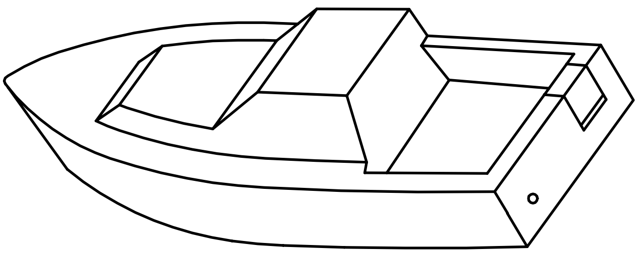
b) Open transom with semi-fixed sill



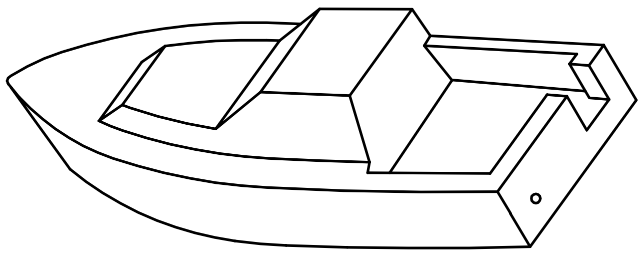
c) Bridge-deck with semi-fixed sill



d) Raised sole with fixed sill



e) Transom door with bottom gap



f) Opening in the transom

Key

1 Waterline
2 Cockpit bottom
3 Overflow point
4 Coamings
5 Seats
6 Drain
7 Access companionway
8 Top of the fixed part
9 Top of the mobile part
10 Bridge deck
11 Sole or grating
12 Grating flowing section at least 3 times the drain section
13 No fixed sill if washboards exist

a H_B and h_C measured at the centre of the cockpit bottom

Figure A.1 — Examples of single-plane cockpit bottom

Figures A.1a) to A.1f) illustrate typical cases.

Figure A.1a) shows that H_B and h_C are measured from the centre of the bottom surface. Sill heights are measured from the closest point of the bottom.

Figure A.1b) shows that, if there is no cockpit water retention, $h_C = 0$ and the draining time is 0. A minimum sill height is, however, required.

Figure A.1c) shows the case of cockpit with a bridge-deck.

Figure A.1d) shows the case of a raised sole, such as a grating, which does not alter the sill requirements above the cockpit bottom. The grating shall in no way impair the efficiency of the draining, and shall provide an ample flow section. Figure A.1d) suggests 3 times the drain section to consider additional pressure losses in a multi-hole device. The grating flow section can be analysed using normative annex D, or the draining time can be measured.

Figure A.1d) also shows that, unlike examples a, b, and c, the companionway door is made of washboards. There is no semi-fixed sill, and the fixed sill is measured to the top of the bridge deck or the lowest point of the washboard framing, whichever is the lower.

Figure A.1e) shows a typical motorboat with a door in the transom. If there is a door, it shall be considered to be closed. The gap between the door and its lower sill is considered to be a drain freeing port, probably with little losses due to friction, according to its shape and size. Its dimensions may be largely sufficient for draining time requirements. But 7.1 (90 % of cockpit shall drain at 10° heel) may require an additional drain on the port side.

Figure A.1f) shows the same boat with an opening in the transom. The boat may be considered to have an open transom, but 7.1 may still require an additional drain on the port side.

Annex B
(normative)

Analysis of multi-level cockpit bottom

B.1 General

A cockpit may have several different surfaces comprising the cockpit “bottom”, a cockpit bottom being a “surface where water collects before being drained”.

Sill-height assessment may be subject to various interpretations. The following interpretations also cover "foot wells" in front of the main companionway that artificially raises sill-height measurements.

B.2 General basis of interpretation

B.2.1 Introduction

Sills are intended to prevent ingress of water into the boat when the companionway door or hatch is open.

In fair weather, the semi-fixed sill is not assumed to be in place and only the fixed part of the sill is available. In that case, the amount of water that can enter the cockpit is moderate.

As the weather and sea state worsen, the semi-fixed sill is raised. Then in bad conditions, where the cockpit may be filled up, the companionway door is closed.

The amount of water brought by an unexpected wave has to be evaluated.

A simple evaluation is to suppose that this wave fills the entire cockpit horizontal projection with a uniform layer of water having a thickness equal to $h_{s,min}$. The value of $h_{s,min}$ is related to the design category, i.e. with the severity of the expected weather.

The analysis of the cockpit geometry considers two instants in time:

— initially, when this water is poured (instantaneously) into the cockpit;

— a few seconds later, when the water has flowed into the various recesses where it begins to be drained overboard.

B.2.2 Initially

The water shall not reach inside the non-quick-draining part of the boat. For a cockpit bottom comprising a simple plane, this is obviously the case as the sill height is $h_{s,min}$ everywhere.

Consequently, each bottom plane shall have a local sill height of at least $h_{s,min}$.

The definition of a bridge deck will make it ineligible as a bottom if its area is limited. Larger bridge decks may be considered to be one of the bottom levels.

B.2.3 When water has flowed into all the recesses

a) The centre of the surface of the lowest bottom of these recesses shall be the point where H_B is measured.

If a long time is required to drain the cockpit from a height of $h_{s,min}$, there will be a risk of water entering into the inside.

b) Therefore no significant amount of the water contained in these recesses shall flow into the boat.

This condition is **met** if the sills of the different recesses are above the level of the water contained.

This condition is **approached** if the drainage flow is at least equal to the flow passing through the companion-way opening. The latter requirement will be considered to be met if the draining time is less than $0{,}05t_{max}$, as defined in 7.2.

The requirements corresponding to the above interpretations are specified in B.3.

B.3 Requirements for multilevel cockpits

B.3.1 Minimum local sill heights

Each one of the cockpit bottom planes shall have a local sill height of at least $h_{s,min}$ for a fixed sill or $h_{s,min}/2$ for the fixed part of a semi-fixed sill as defined in Table 5.

B.3.2 General cockpit bottom

The centre of surface of the lowest of the bottom planes shall be the point from which H_B is measured.

B.3.3 Local sill heights

It is assumed that the entire cockpit horizontal projection has been covered with a uniform layer of water having a thickness equal to $h_{s,min}$ and that this water has flowed towards the parts of the cockpit from where it is drained.

At this instant, one of the following conditions shall be met.

— Alternative 1: The local sills of the different parts are **above** the level of the water contained, and fulfil the relevant requirements of Table 5.

— Alternative 2: The local sills fulfil the relevant requirements of Table 5 but are **below** the level of the water contained, then the drainage time to **fully** drain each part shall be less than $0{,}05t_{max}$.

If an area gives onto two different parts, its water shall be considered as flowing equally into each part.

If an area gives onto more than two parts, its water shall be separated according to the proportion of each projected area to the total projected area.

Some examples of such an analysis are given in B.4.

B.4 Analysis example of different examples

B.4.1 Introduction

In the examples of B.4.2 and B.4.3, the calculations are made for a set of two drains with their outlet below the waterline and no elbow, a case corresponding to the third line of Table 4.

B.4.2 Example 1 (see Figure B.1a)

B.4.2.1 Requirements

Non-sailing boat, design category C, L_H = 8 m, B_{max} = 2,5 m, F_M = 1 m, hence $L_H \times B_{max} \times F_M$ = 20 m^3.

Cockpit dimensions: 2 m wide × 2,8 m long × 0,65 m deep (the average cockpit height h_C = 0,65 m), hence: the cockpit bottom area is 2 × 2,8 = 5,6 m^2.

The cockpit volume is 5,6 × 0,65 = 3,64 m^3 and k_C = 3,64/20 = 0,182.

As the boat is in design category C, non-sailing boat: t_{max} = 0,6/k_C = 0,6/0,182 = 3,3 min, and $h_{s,min}$ = 0,1 m.

If two drains are fitted, t_{ref} = 3,3/3,64 = 0,91 min and, according to Table 4, third line $d \approx$ 80 mm.

If four drains are fitted, the cockpit volume per set of two drains will be 1,82 m^3, t_{ref} = 1,81 min and, according to Table 4, $d \approx$ 57 mm.

For any reason, probably to avoid any sill between the main cockpit level (part B of the cockpit) and the companionway opening, a "foot basin" covered by a grating has been installed by the boat builder.

As in most motor boats, the companionway door is hinged or sliding, which constitutes a door with a semi-fixed sill.

The cockpit is made of three parts: A, B and C.

Part A has a bottom 2 m wide and 1,5 m long, hence an area S_A = 3 m^2.

Part C is the front "foot basin" and its bottom is 0,9 m wide × 0,6 m long, hence S_C = 0,54 m^2. Its depth is 0,3 m.

Part B is the rest of the cockpit, and its bottom area is the total bottom area minus the bottom areas of parts A and C, it has an area S_B = 5,6 – 3 – 0,54 = 2,06 m^2.

If the cockpit is covered with $h_{s,min}$ = 0,1 m of water, half of the water in part B may be considered to flow into part A, and the rest into part C.

The various plan areas, volumes and height of water in parts A, B, C and Total are summarized in Table B.1.

Table B.1

Parameter	A	B	C	Total
Plan area, (m^2)	3,0	2,06	0,54	5,6
Volume contained (m^3) after initial filling of 0,1 m	0,3	0,206	0,054	0,56
Volume contained (m^3), when B flows into A and C	0,403	0	0,157	0,56
Height of water in part C (m) after flowing			0,157/0,54 = 0,29	

B.4.2.2 Using Alternative 1 of B.3.3

Volume C is 0,3 m deep and will be filled up to 0,157/ 0,54 = 0,29 m, which is only 1 cm below the sill.

Consequently, if the drain size is "normal", i.e. four drains of diameter 57 mm, the sill of the foot basin shall be at least 0,29 m high from the bottom of C, which means about the same level as the bottom of B.

If the builder wishes the cabin entry to be easier, and the local sill of part C is to be 0,05 m, as allowed in Table 5 (top of fixed part) Alternative 2 of B.3.3 shall be used, since using Alternative 1 the actual sill height would be considered too low.

B.4.2.3 Using Alternative 2 of B.3.3

Table 4 can no longer be used by the boat builder, as the requirement of Alternative 2 is **full draining** (Table 4 considers a remainder of 0,1 m). Normally, equation D.8 should be used but, for simplicity, equation D.3 is used.

The volume of 0,157 m^3 contained in part C shall drain in $t_{max} \times 0,05 = 3,3 \times 0,05 = 0,165$ min = 10 s. Therefore, to achieve a full drain of volume C within this time with a set of two drains, the drain diameter needs to be:

$$d = \sqrt{\frac{4\,791 \times V_C}{t_1 \sqrt{h_c}}} = \sqrt{\frac{4\,791 \times 0,157}{0,165\sqrt{0,3}}} = 91\,\text{mm}$$

However, if friction losses for outlets below the waterline and $d \approx 100$ mm are considered, Table C.4 gives $C_3 \approx 1,5$, which means that the draining time will be increased by 50 %.

Consequently, the above formula should be computed with a draining time of 0,165/1,5 = 0,11 min, and finally give

$$d = \sqrt{\frac{4\,791 \times 0,157}{0,11 \times \sqrt{0,3}}} = 111\,\text{mm}$$

this is about double the 57 mm required by Alternative 1 (4 drains).

In conclusion, in the above example for part C of the cockpit, one shall either

- use B.4.2.2 and have a fixed sill height h_s of 0,3 m with «normal drains» corresponding to the draining-time requirement of 7.2, and can therefore have a grating covering area C with no «apparent» sill, or
- use B.4.2.3 and part C shall be fitted with two drains that are much larger (110 mm diameter in the example), and have a local sill height $h_{s,min}/2$ corresponding to the relevant column of Table 5.

B.4.3 Example 2 [see Figure B.1b)]

B.4.3.1 Requirements

The same non-sailing boat as specified in B.4.2, but the cockpit with only two parts, B and C.

Part C is the same as in example 1 and $S_B = 5,6 - 0,54 = 5,06$ m^2. If the cockpit is covered with 0,1 m of water, the volume contained in B will flow into C.

B.4.3.2 Using Alternative 1 of B.3.3

When the water has flowed from B to C, the volume flowing towards C will be 5,06 × 0,10 = 0,56 m^3.

Volume C being 0,3 m deep, it contains, when full, 0,54 × 0,3 = 0,162 m^3. The rest is still contained in part B and the residual water height above the top of C is (0,56 – 0,162)/5,6 = 0,071 m. Hence the sill height shall be 0,3 + 0,07 = 0,37 m which is 0,07 m above the bottom of B, whereas with a one-level bottom this height $h_{s,min}$ would be 0,05 m above the same bottom of B.

B.4.3.3 Using Alternative 2 of B.3.3

If the boat builder wishes to have the sill height equal to $h_{s,min}$ = 0,05 m from the bottom of C, the 0,56 m^3 contained in the cockpit shall drain in the same 0,165/1,5 = 0,11 min as in Example 1 and the drain diameter of the two drains shall in fact be

$$d = \sqrt{\frac{4\,791 \times 0{,}56}{0{,}11 \times \sqrt{0{,}37}}} = 200 \text{ mm}$$

In conclusion to the two previous examples, the use of Alternative 1 may allow lower sills from the **bottom of part B**, thanks to part C, but this height is governed by the ratio between the volume of the different parts of the cockpit.

Alternative 2 allows the sill height $h_{s,min}$ to be used above the **bottom of part C**, but with considerably bigger drains.

B.4.4 Example 3 [see Figure B.1c)]

B.4.4.1 Requirements

Example 3 corresponds to a typical catamaran layout (a sliding hatch in top of the roof would impair the torsional stiffness).

L_H = 13 m, B_{max} = 7 m, F_M = 1,5 m, hence $L_H \times B_{max} \times F_M$ = 136,5 m^3.

Cockpit dimensions:

Part C (footwell): 0,6 m long, 0,6 m wide, 0,5 m deep.	S_C = 0,6 × 0,6 = 0,36 m^2	V_C = 0,36 × 0,5 = 0,18 m^3
Part B (top): 3,2 m long, 2,1 m wide, 0,4 m deep.	S_B = 3,2 × 2,1 − 0,36 = 6,36 m^2	V_B = 6,36 × 0,4 = 2,54 m^3
Total	S_{tot} = 3,2 × 2,1 = 6,72 m^2	V_C = 6,72 × 0,4 + 0,18 = 2,87 m^3

then k_C = 2,87/136,5 = 0,021 and, for a multihull in category A, t_{max} = 0,3/k_C = 14,2 min, but limited to 5 min.

Equation D.3 gives

$$d = \sqrt{\frac{4\,791 \times V_C}{t_1 \times \sqrt{h_C}}\left(1 - \sqrt{\frac{0{,}1}{h_C}}\right)} = \sqrt{\frac{4\,791 \times 2{,}87}{5\sqrt{0{,}4}}\left(1 - \sqrt{\frac{0{,}1}{0{,}4}}\right)} = 47 \text{ mm}$$ if there are two drains or 47 × 0,707 = 33 if there are four drains.

For multihulls in category A, the fixed sill height $h_{s,min}$ = 0,2 m, and this height, with a one-plane bottom, shall be measured above the bottom of part B.

B.4.4.2 Using alternative 1 of B.3.3

The cockpit is considered to be covered with 0,2 m of water. If the drains of the upper level are not significantly bigger than 47 mm, the great majority of the water of part B may be considered to flow into part C before being drained.

Hence volume C shall contain 6,72 × 0,2 = 1,34 m^3. As volume C is 0,5 m deep, it contains 0,36 × 0,5 = 0,18 m^3. The rest is contained in part B. The additional fill height is (1,34 − 0,18)/6,36 = 0,18 m, hence the sill height shall be 0,50 + 0,18 = 0,68 m above the bottom of C, and 0,18 m above the bottom of B.

B.4.4.3 Using alternative 2 of B.3.3

As the sliding door is a semi-fixed device, the required fixed part of the sill minimum height $h_{s,min}/2$ = 0,1 m. If one wants to use this height, the 1,34 m^3 contained in volume B + C shall drain in 5 min × 0,05 = 0,25 min, and to have this draining time with two drains to fully drain it, the following is required:

$$d = \sqrt{\frac{4\,791 V_C}{t_1\sqrt{h}}} = \sqrt{\frac{4\,791 \times 1{,}34}{0{,}25\sqrt{0{,}68}}} = 176 \text{ mm}$$ if there are two drains and 125 mm if there are four drains.

In this case, the friction losses are very small due to the large drain size and discharge above the waterline with no pipe.

However, if the two drains in part B are significantly bigger than 47 mm, e.g. 125 mm, half of the volume of B can be considered drained overboard while the rest flows into C.

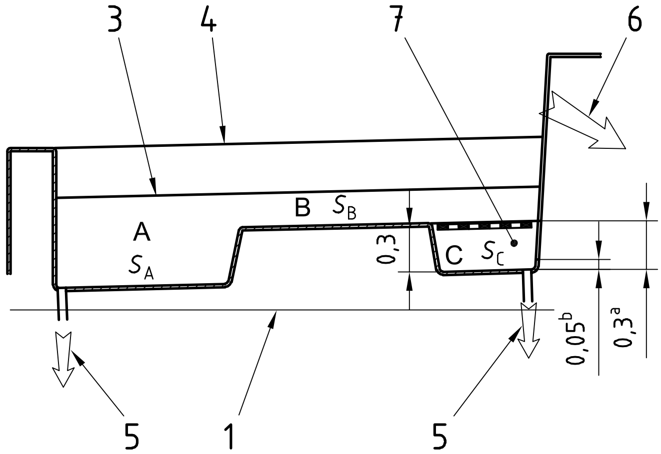
Using alternative 1, the fill height of water in C is 0,5 + [(6,36/2 + 0,36) 0,2]/6,36 = 0,61 m.

Using alternative 2, the volume to be fully drained by the drains of C is (6,36/2 + 0,36)0,2 = 0,708 m^3, and

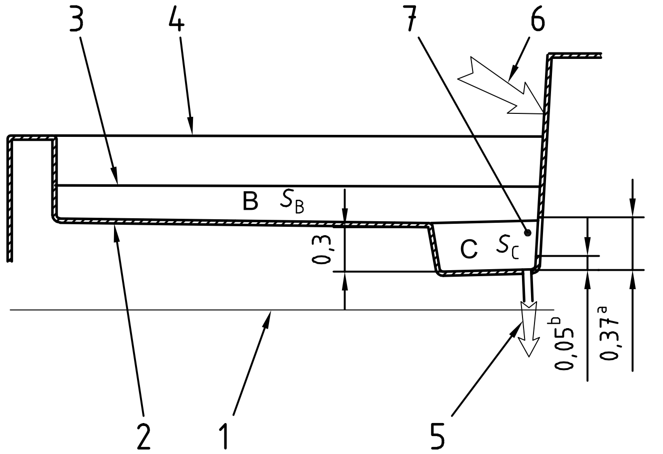
$$d = \sqrt{\frac{4\,791 V_C}{t_1\sqrt{h}}} = \sqrt{\frac{4\,791 \times 0{,}708}{0{,}25\sqrt{0{,}61}}} = d = 132 \text{ mm}$$ if there are two drains and 93 mm if there are four drains.

Consequently, the final requirement of Alternative 2 is four drains with d = 93 mm in C and two drains with d = 125 mm in B.

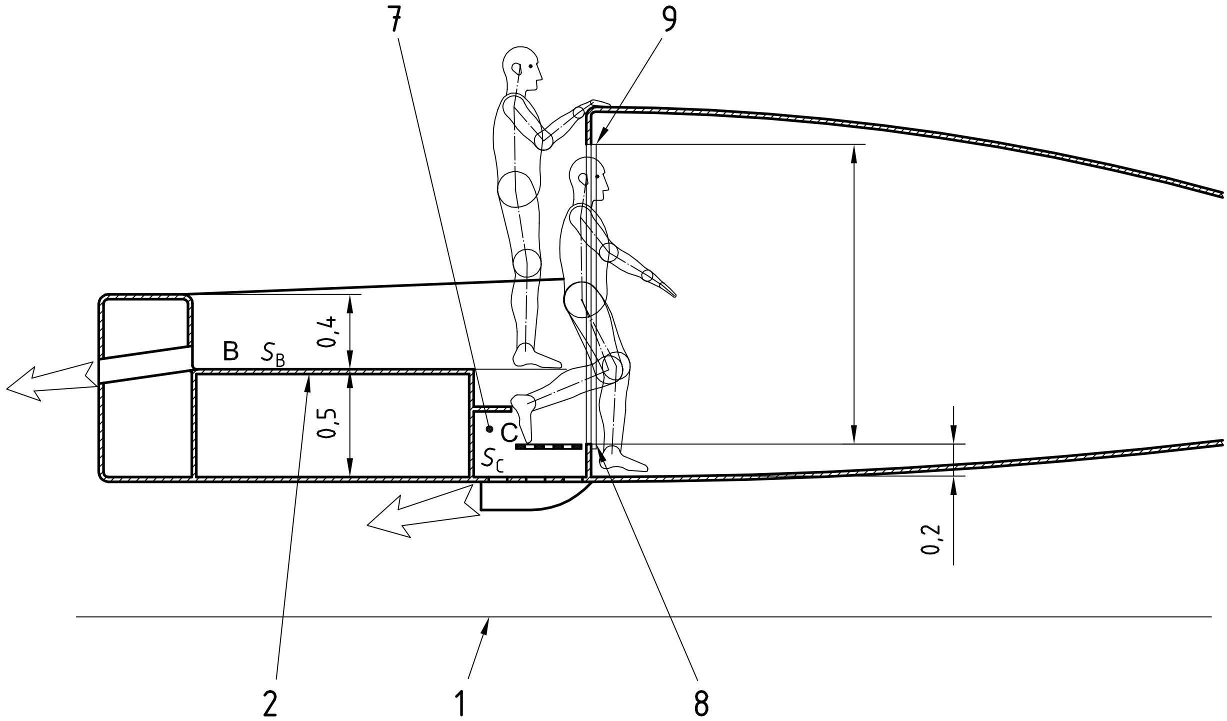
Dimensions in metres



a) Example 1



b) Example 2



c) Example 3

Key

1 Waterline
2 Cockpit bottom
3 Coamings
4 Seats
5 Drain
6 Access companionway
7 Foot basin
8 Top of fixed part of semi-fixed sill
9 Top of mobile part of semi-fixed sill

[a] Alternative 1
[b] Alternative 2

Figure B.1 — Examples of multi-level cockpit analysis

Annex C
(normative)

Draining time calculation using tables

C.1 Introduction

The following method is an application of the theoretical calculations explained in normative annex D.

C.2 Step 1: Determination of t_{max}, required maximum draining time

According to 7.2, determine t_{max} using the cockpit volume coefficient, $k_C = V_C/(L_H\, B_{max}\, F_M)$

t_{max} is $0,3/k_C$ in design category A, $0,45/k_C$ in category B, $0,6/k_C$ in category C, and $0,9/k_C$ in category D.

C.3 Step 2: Determination of t_{ref}, reference draining time

Calculate $t_{ref} = t_{max}/(V_C)$, which is the reference draining time (without head loss) for a set of two drains.

C.4 Step 3: Determination of coefficient C_1

The coefficient C_1 is due to the difference between h_C and 0,4 m.

Enter Table C.1 with the value of h_C and find the value of C_1.

Remember that h_C is the actual value for drains above the waterline, but h_C is the height from top of water in the cockpit to the waterline if drains are below the waterline.

Table C.1 — Values of C_1 as a function of h

h_C (m)	0,20	0,30	0,40	0,50	0,60	0,70	0,80	0,90	1,00	1,10	1,20	1,30	1,40	1,50	1,60	1,70	1,80	1,90	2,00
$C_1 = (t_{1,hc}/t_{1,04})$	0,83	0,98	1,00	0,99	0,97	0,94	0,91	0,89	0,86	0,84	0,82	0,80	0,78	0,77	0,75	0,73	0,72	0,71	0,69

C.5 Step 4: Determination of drain diameter with head losses

The values used to enter Table C.2 are

— $t_{ref}/(C_1\, C_2)$ for drains located above the waterline, C_2 is given by Table C.3 or Figure C.1,

— $t_{ref}/(C_1\, C_3)$ for drains located below the waterline, C_3 is given by Table C.4 or Figure C.2.

The steps to follow are:

To obtain a first rough estimate of the drain diameter d, enter Table 4 in 7.8.4.4 with a draining time immediately quicker than the above t_{ref}, and select a first corresponding diameter d.

With drain diameter d, expressed in millimetres, and drain length L, expressed in metres, enter

— Table C.3 or Figure C.1 if the drain outlet is above the waterline, and find C_2,

— Table C.4 or Figure C.2 if the drain outlet is below the waterline, and find C_3.

Enter Table C.2 with t_{ref}/C_1C_2 or t_{ref}/C_1C_3, and find the diameter immediately superior to the one corresponding to the time required. Interpolations can be made.

Table C.2 — Drain diameter as a function of $t_{ref}/(C_1C_2)$ of $t_{ref}/(C_1C_3)$

$t_{ref}/(C_1C_2)$ or $t_{ref}/(C_1C_3)$	9,47	6.06	4,21	3,09	2,37	1,87	1,52	1,25	1,05	0,90	0,77	0,67	0,59	0,47	0,38	0,31	0,26	0,22	0,19	0,17
Drain diameter (mm)	20	25	30	35	40	45	50	55	60	65	70	75	80	90	100	110	120	130	140	150
Drain section (cm^2)	3	5	7	10	13	16	20	24	28	33	38	44	50	64	79	95	113	133	154	177

C.6 Example of calculation

A boat has the following parameters:

L_H = 8 m, B_{max} = 3 m, F_M = 1,3 m, cockpit volume V_C =4 m^3, h_C = 0,7 m, design category: B. There are two drains, L = 0,6 m, discharging below the waterline.

Step 1; Calculate $k_C = 4/(8 \times 3 \times 1,3) = 0,128$, then $t_{max} = 0,45/0,128 = 3,51$ min for a category B boat.

Step 2: Calculate $t_{ref} = t_{max}/V_C = 3,51/4 = 0,88$ min.

Step 3: Enter Table 4 with t_{ref} third line: Two drains below the waterline, no elbow, with t_{ref} = 0,9, and find d = 80. As this value is somewhat conservative, d will be smaller.

— With h_C = 0,7 m, Table C.1 gives C_1 = 0,94.

Step 4: With d one size smaller than 80, i.e. 70, Table C.4 (drain outlet below the waterline) for a drain length of 0,6 m gives for d = 70, C_3 = 1,48.

— Calculate $t_{ref}/(C_1C_3) = 0,88/(0,94 \cdot 1,48) = 0,63$ min.

— Enter Table C.2, with $t_{ref}/(C_1C_3)$ = 0,63, and d will prove to be close to 77 mm.

In this example, one can see that, in many cases, the "rough" use of table 4 is maybe a little conservative (e.g. we find 80 mm instead of 77 mm) but is much easier to use than the "exact" method.

For drain diameters much greater than 40 mm, the difference between the use of Table 4 and the exact method is small. This would not be the case for smaller drain diameters.

Tables C.3 and C.4, and corresponding Figures C.1 and C.2 are for a draining system with two drains.

Table C.3 — Values of C_2 for h_C = 0,4 m and drain outlet above the waterline

Drain length L (m)		0,20	0,40	0,60	0,80	1,00	1,20
Drain diameter d (mm) =	**25**	1,10	1,18	1,25	1,32	1,38	1,45
	30	1,09	1,15	1,21	1,26	1,31	1,37
	35	1,08	1,13	1,18	1,22	1,27	1,31
	40	1,07	1,11	1,15	1,19	1,23	1,27
	45	1,07	1,10	1,14	1,17	1,21	1,24
	50	1,06	1,09	1,12	1,15	1,18	1,21
	55	1,06	1,09	1,11	1,14	1,17	1,19
	60	1,05	1,08	1,11	1,13	1,15	1,18
	65	1,05	1,08	1,10	1,12	1,14	1,16
	70	1,05	1,07	1,09	1,11	1,13	1,15
	80	1,05	1,06	1,08	1,10	1,12	1,13
	90	1,04	1,06	1,08	1,09	1,11	1,12
	100	1,04	1,06	1,07	1,08	1,10	1,11
	110	1,04	1,05	1,07	1,08	1,09	1,10
	120	1,04	1,05	1,06	1,07	1,08	1,09
	130	1,04	1,05	1,06	1,07	1,08	1,09
	140	1,04	1,05	1,06	1,06	1,07	1,08
	150	1,04	1,05	1,05	1,06	1,07	1,08

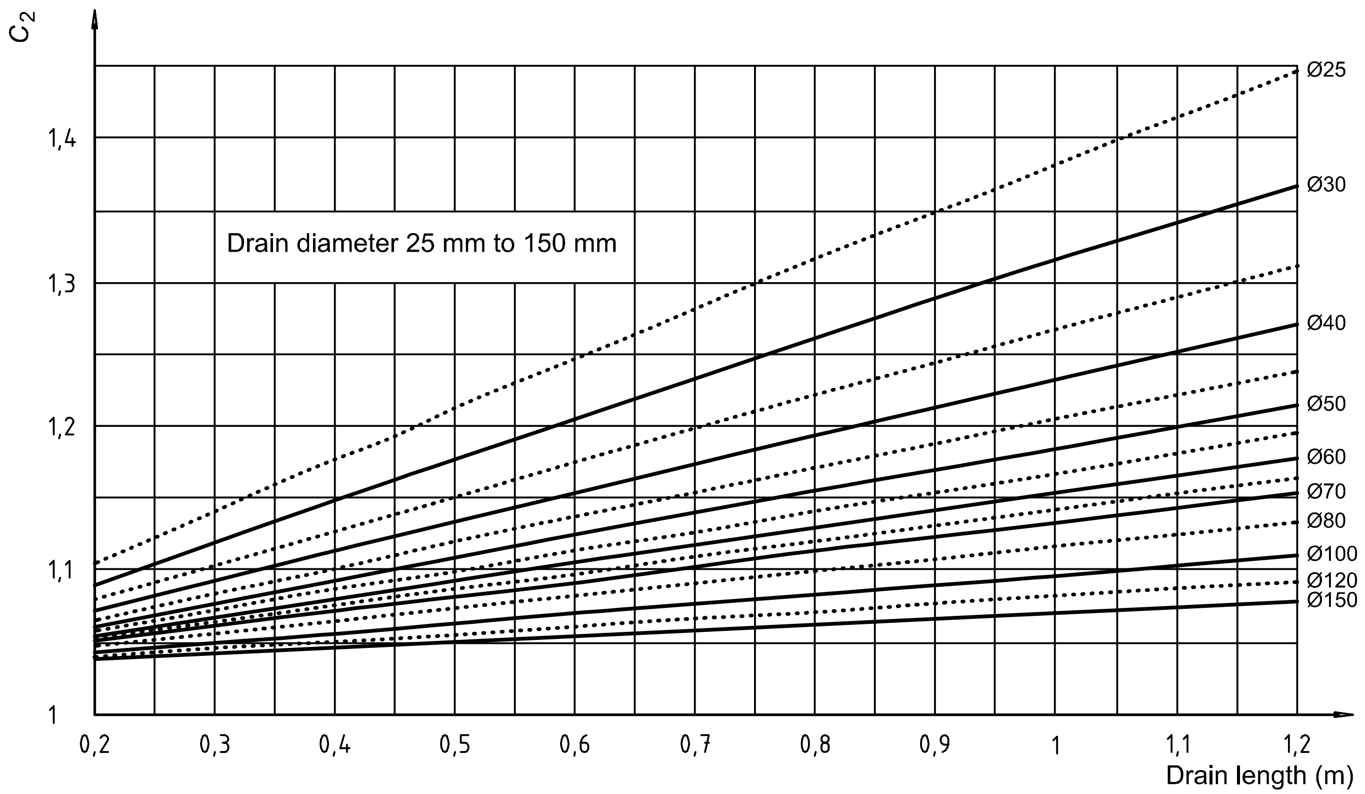


Figure C.1 — Values of C_2 for h_C = 0,4 m for drain outlet above the waterline

Table C.4 — Values of C_3 for h_C = 0,4 m and drain outlet below the waterline

Drain length L (m)		**0,20**	**0,40**	**0,60**	**0,80**	**1,00**	**1,20**
Drain diameter d (mm) =	**25**	1,49	1,55	1,61	1,67	1,72	1,77
	30	1,48	1,53	1,57	1,62	1,66	1,71
	35	1,47	1,51	1,55	1,59	1,63	1,66
	40	1,47	1,50	1,53	1,57	1,60	1,63
	45	1,46	1,49	1,52	1,55	1,58	1,60
	50	1,46	1,49	1,51	1,53	1,56	1,58
	55	1,46	1,48	1,50	1,52	1,54	1,57
	60	1,46	1,47	1,49	1,51	1,53	1,55
	65	1,45	1,47	1,49	1,51	1,52	1,54
	70	1,45	1,47	1,48	1,50	1,52	1,53
	80	1,45	1,46	1,48	1,49	1,50	1,52
	90	1,45	1,46	1,47	1,48	1,49	1,51
	100	1,45	1,46	1,47	1,48	1,49	1,50
	110	1,44	1,45	1,46	1,47	1,48	1,49
	120	1,44	1,45	1,46	1,47	1,48	1,49
	130	1,44	1,45	1,46	1,47	1,47	1,48
	140	1,44	1,45	1,46	1,46	1,47	1,48
	150	1,44	1,45	1,45	1,46	1,47	1,47

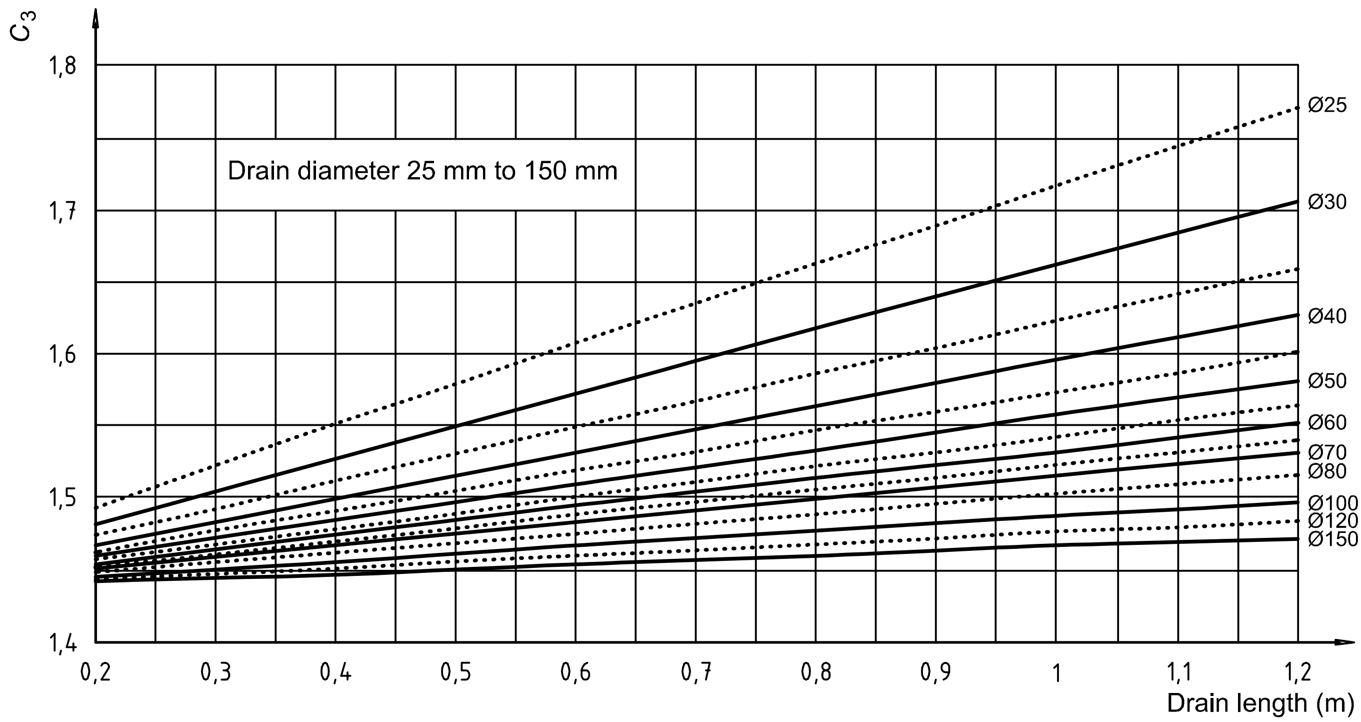


Figure C.2 — Values of C_3 for h_C = 0,4 m for drain outlet below the waterline

Annex D
(normative)

Alternative method of calculation — Direct calculation with head losses

D.1 Symbols and units

In this annex, the following symbols and units are used:

U is the flow speed of the water, expressed in metres per second.

g is the acceleration due to gravity = 9,81 m/s^2.

h is the instant height of water in the cockpit, in metres.

d is the drain diameter, in millimetres, two drains are assumed.

D is the drain diameter, in metres two drains are assumed.

V_C, h_C and t_{ref} are already defined, in clause 4.

D.2 Calculation without head losses

D.2.1 Flow speed

The flow speed, in metres per second, at the entry of the drain for any height of water h in the cockpit is calculated as follows:

$$U = \sqrt{2gh} = 4{,}43\sqrt{h} \qquad \text{(D.1)}$$

D.2.2 To fully drain the cockpit

$$t = \frac{4\,791 \times V_c}{d^2\sqrt{h_c}}$$ with t expressed in minutes and two drains d in millimetres (D.2), or

$$d = \sqrt{\frac{4\,791 \times V_c}{t\sqrt{h_c}}} \qquad \text{(D.3)}$$

D.2.3 To partially drain the cockpit

To drain the cockpit between h_c and a remaining 0,1 m with t_l in minutes and 2 drains d in millimetres.

$$t = \frac{4\,791\,V_c}{d^2\sqrt{h_c}}\left(1 - \sqrt{\frac{0{,}1}{h_c}}\right) \qquad \text{(D.4), or}$$

$$d = \frac{4\,791\,V_c}{t\sqrt{h_c}}\left(1 - \sqrt{\frac{0{,}1}{h_c}}\right) \qquad \text{(D.5)}$$

For the “basic” cockpit height of 0,4 m

$$d = \sqrt{\frac{3\,788\,V_c}{t}} \qquad \text{(D.6)}$$

For a freeing port without flap, there is no additional head loss, but the "effective" section is contracted by a factor of 0,6, and equation D.6 inverted becomes:

$$\frac{t}{V_C} = t_{ref} = \frac{3\,788}{(0{,}6d^2)} \qquad \text{(D.7)}$$

D.3 Calculation with head losses

D.3.1 New flow speed

The term concept "pressure head" defines an equivalent height of water in the Bernoulli equation.

$$h + U^2/2g = \text{Constant.}$$

Frictions or flow discontinuities within the draining system create losses of pressure head, flow speed reduction, and hence increased draining time.

Friction causes pressure head losses and flow discontinuities create additional losses.

The new head is $h_c - \delta_h$, δ_h being the total of the losses, and the new flow speed is

$$U = 4{,}43\sqrt{h_c - \sum \delta_h} \qquad \text{(D.8)}$$

D.3.2 Frictional pressure losses

For smooth drains, frictional pressure losses are

$$\delta_h = 4{,}85 \times 10^{-4} \times \frac{L_d U^{1{,}75}}{D^{1{,}25}}$$

where

L_d is the length, in metres, of the drain;

U is the drain flow speed, in metres per second;

D is the drain diameter, in metres.

D.3.3 Additional head losses

Additional head losses are due to flow discontinuities (at the entrance and outlet of the pipe, elbows, etc.) and are usually written in the following form:

$$\delta_h = \sum KU^2/2g$$

where $\sum K$ is the sum of all the additional losses.

Typical values of additional head losses are listed in table D1:

Table D.1 — Values of K for various discontinuities

Type of discontinuity	K
Entry sharp angle	0,5
Entry chamfered	01 to 0,5
Entry rounded angle	0,06
Outlet, discharge above the waterline	0
Outlet, discharge below the waterline	1
Round elbow	0,1 to 0,5
Sharp elbow	0,5 to 1,3
Grid of round holes	0,5 to 3

NOTE Additional head losses other than the main ones listed in Table D.1 could be found. Any existing data enabling more precise assessments of K can be used instead of the approximations in Table D.1.

D.3.4 Emptying time calculation with pressure head losses

To avoid confusion, the different flow speeds U_i and draining time t_i are referred to in accordance with the type of head losses, as follows:

— U_1, (m/s), and t_1 (min): without head losses;

— U_2, (m/s), and t_2 (min): with head losses and drain outlet above the waterline;

— U_3, (m/s), and t_3 (min): with head losses and drain outlet below the waterline.

After calculating the draining time without head losses t_1, as explained in clause D.2, calculate the flow speed U_2 or U_3 whichever is pertinent at mid draining height $h_m = (h_C + 0,1)/2$.

Flow speed with head losses U_2 or $U_3 = 4,43\sqrt{h_m - \sum \delta_h}$

$$U_i - 4,43\sqrt{h_m - 4,85 \times 10^{-4} \times \frac{LU_i^{1,75}}{D^{1,25}} - 0,051\sum KiU_i^2} = 0 \qquad \text{(D.9)}$$

with U_i expressed in metres per second. D and L in metres and i = 2 or 3.

Equation D.9 is implicit, and therefore, it is necessary to find U_i such that the first term of the equation equals 0 (most of the spreadsheet softwares have a "solver" function directly solving this equation by iterations). The draining time with head losses can therefore be approximated as $t_i = t_1 U_1 / U_i$.

For boat builders not wishing to enter the above calculations, precalculated tables and graphs to help find the approximate draining time have been computed for the tables of normative annex C.

Table 4 is also a pre-calculated table with typical drain arrangements.

Annex E
(normative)

Watertightness tests

E.1 Introduction

NOTE The following tests are optional. If performed however, the procedures described in clauses E.2 and E.3 apply.

E.2 Degree of watertightness 2 and 3

The appliance shall be tested with a water jet positioned outside of the craft, and in accordance with Figure E.1 for horizontal appliances or oriented up to 45° against the horizontal, or in accordance with Figure E.2 for vertical appliances or oriented up to 45° against the vertical.

The water jet shall be a dense, thin, water jet delivering a flow of at least 10 l/min, aiming everywhere in an area located within 0,05 m each side of the periphery of the appliance. See Figures E.1 and E.2.

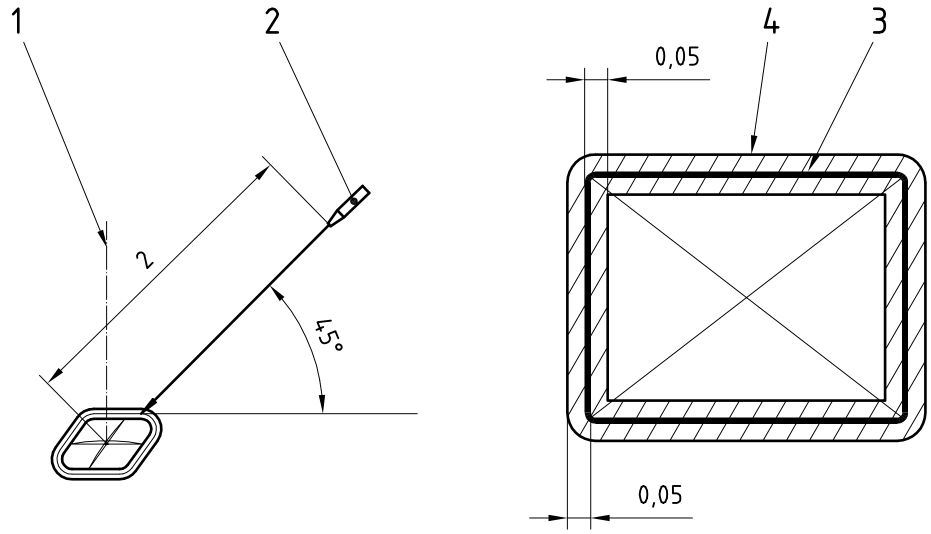
NOTE This jet is normally attained when connecting a garden hose with an adjustable nozzle to a tap, the static pressure of which, when the tap is closed, is 200 kPa.

Spraying shall continue for at least 3 min. After this duration, the ingress of water shall not exceed

— 0,05 litres for appliances that conform to degree of watertightness 2, or

— 0,5 litres for appliances that conform to degree of watertightness 3.

Dimensions in metres



Key

1 Perpendicular

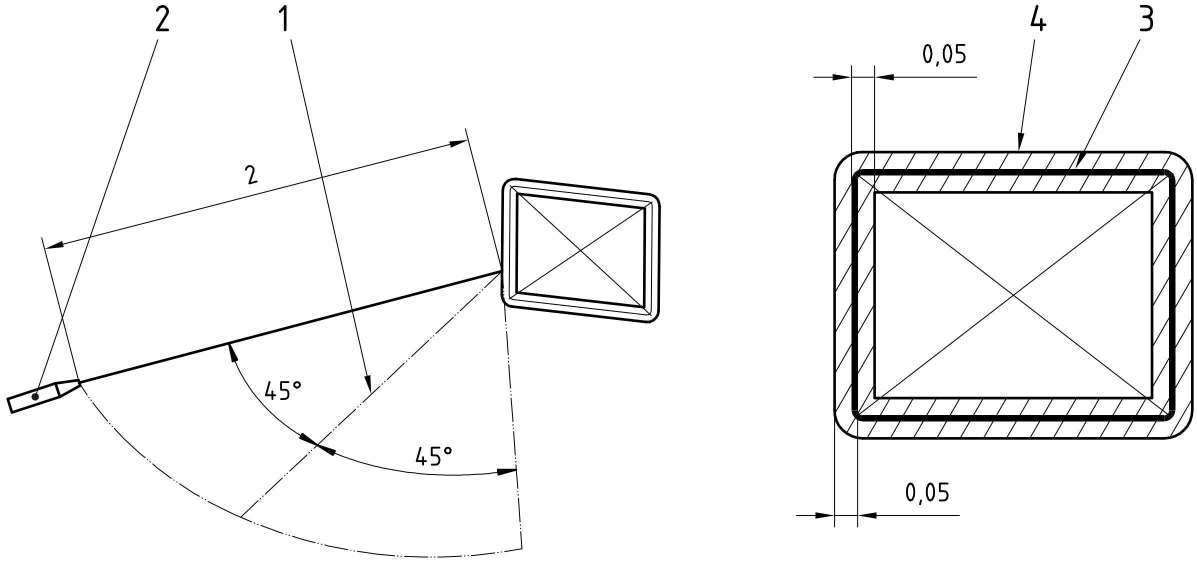
2 Nozzle

3 Appliance periphery

4 Hatched area at which the jet is to be aimed

Figure E.1 — Test arrangement for horizontal appliances or oriented up to 45° against the horizontal

Dimensions in metres



Key

1 Perpendicular

2 Nozzle

3 Appliance periphery

4 Hatched area where the jet is to be projected

Figure E.2 — Test arrangement for vertical appliances or oriented up to 45° against the vertical

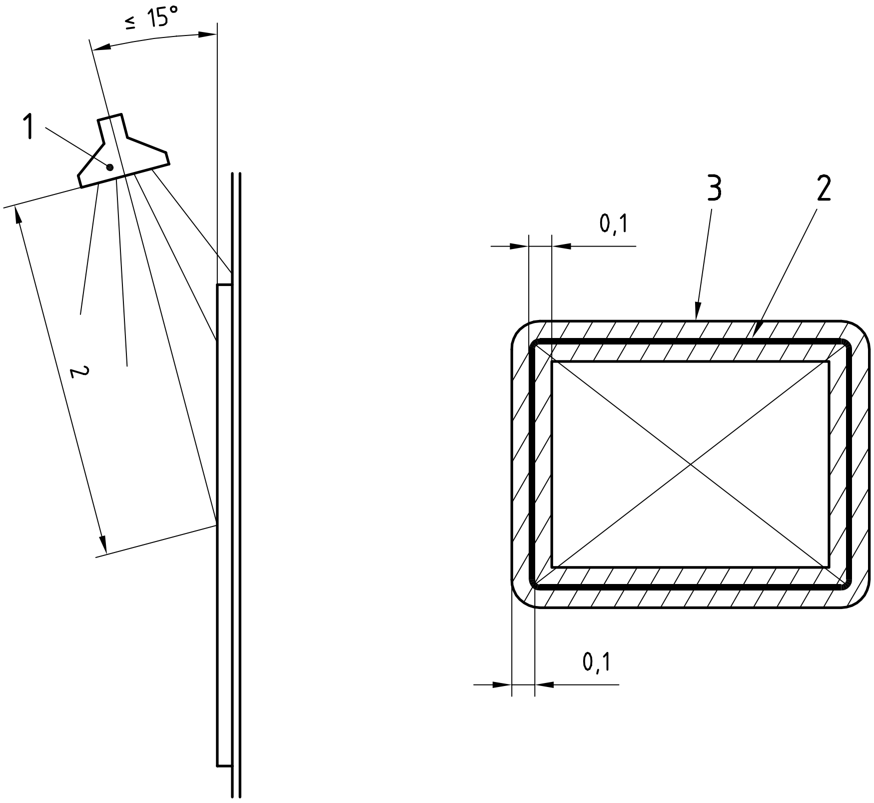
E.3 Test for determination of degree of watertightness 4

Unless already tested in accordance with clause E.2, the appliance shall be tested with a spray nozzle positioned outside of the craft, and in accordance with Figure E.3.

This spray nozzle shall be able to simulate heavy rain. No water pressure is specified.

Spraying shall continue for at least 3 min. After this duration, the ingress of water shall not exceed 0,5 litres.

Dimensions in metres



Key

1 Nozzle

2 Appliance periphery

3 Hatched area at which the jet is to be aimed

Figure E.3 — Test arrangement for determination of degree of watertightness 4

Bibliography

[1] G. DOLTO Technical Background of ISO 11812, ISO/TC 188 Internal document

ICS 47.080

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