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Personal flotation devices —

Part 9: Test methods

Équipements individuels de flottabilité —

Partie 9: Méthodes d'essai

Reference number
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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 12402-9 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 162, *Protective clothing including hand and arm protection and lifejackets*, in collaboration with Technical Committee ISO/TC 188, *Small craft*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 12402 consists of the following parts, under the general title *Personal flotation devices*:

— *Part 1: Lifejackets for seagoing ships — Safety requirements*

— *Part 2: Lifejackets, performance level 275 — Safety requirements*

— *Part 3: Lifejackets, performance level 150 — Safety requirements*

— *Part 4: Lifejackets, performance level 100 — Safety requirements*

— *Part 5: Buoyancy aids (level 50) — Safety requirements*

— *Part 6: Special purpose lifejackets and buoyancy aids — Safety requirements and additional test methods*

— *Part 7: Materials and components — Safety requirements and test methods*

— *Part 8: Accessories — Safety requirements and test methods*

— *Part 9: Test methods*

— *Part 10: Selection and application of personal flotation devices and other relevant devices*

Introduction

ISO 12402 has been prepared to give guidance on the design and application of personal flotation devices (hereafter referred to as PFDs) for persons engaged in activities, whether in relation to their work or their leisure, in or near water. PFDs manufactured, selected, and maintained to this standard should give a reasonable assurance of safety from drowning to a person who is immersed in water.

Requirements for lifejackets on large, commercial seagoing ships are regulated by the International Maritime Organization (IMO) under the International Convention for the Safety of Life at Sea (SOLAS). ISO 12402-1 addresses lifejackets for seagoing ships.

ISO 12402 allows for the buoyancy of a PFD to be provided by a wide variety of materials or designs, some of which may require preparation before entering the water (e.g. inflation of chambers by gas from a cylinder or blown in orally). However, PFDs can be divided into the following two main classes:

— those which provide face up in-water support to the user regardless of physical conditions (lifejackets), and

— those which require the user to make swimming and other postural movements to position the user with the face out of the water (buoyancy aids).

Within these main two classes there are a number of levels of support, types of buoyancy, activation methods for inflatable devices, and auxiliary items (such as location aids), all of which will affect the user‘s probability of survival. Within the different types of buoyancy allowed, inflatable PFDs either provide full buoyancy without any user intervention other than arming (i.e. PFDs inflated by a fully automatic method) or require the user to initiate the inflation. Hybrid PFDs always provide some buoyancy but rely on the same methods as inflatable PFDs to achieve full buoyancy. With inherently buoyant PFDs, the user only needs to put the PFD on to achieve the performance of its class.

PFDs that do not require intervention (automatically operating PFDs) are suited to activities where persons are likely to enter the water unexpectedly; whereas PFDs requiring intervention (e.g. manually inflated PFDs) are only suitable for use if the user believes there will be sufficient time to produce full buoyancy, or help is close at hand. In every circumstance, the user should ensure that the operation of the PFD is suited to the specific application. The conformity of a PFD to this part of ISO 12402 does not imply that it is suitable for all circumstances. The relative amount of required inspection and maintenance is another factor of paramount importance in the choice and application of specific PFDs.

ISO 12402 is intended to serve as a guide to manufacturers, purchasers, and users of such safety equipment in ensuring that the equipment provides an effective standard of performance in use. Equally essential is the need for the designer to encourage the wearing of the equipment by making it comfortable and attractive for continuous wear on or near water, rather than for it to be stored in a locker for emergency use. Throwable devices and flotation cushions are not covered by this part of ISO 12402. The primary function of a PFD is to support the user in reasonable safety in the water. Within the two classes, alternative attributes make some PFDs better suited to some circumstances than others or make them easier to use and care for than others. Important alternatives allowed by ISO 12402 are the following:

— to provide higher levels of support (levels 100, 150, or 275) that generally float the user with greater water clearance, enabling the user’s efforts to be expended in recovery rather than avoiding waves; or to provide lighter or less bulky PFDs (levels 50 or 100);

— to provide the kinds of flotation (inherently buoyant foam, hybrid, and inflatable) that will accommodate the sometimes conflicting needs of reliability and durability, in-water performance, and continuous wear;

— to provide automatically operating (inherently buoyant or automatically inflated) PFDs that float users without any intervention on their part, except in initially donning the PFD (and regular inspection and rearming of inflatable types), or to provide user control of the inflatable PFD's buoyancy by manual and oral operation; and

— to assist in detection (location aids) and recovery of the user.

PFDs provide various degrees of buoyancy in garments that are light in weight and only as bulky and restrictive as needed for their intended use. They will need to be secure when worn, in order to provide positive support in the water and to allow the user to swim or actively assist herself/himself or others. The PFD selected shall ensure that the user is supported with the mouth and nose clear of the water under the expected conditions of use and the user's ability to assist.

Under certain conditions (such as rough water and waves), the use of watertight and multilayer clothing, which provide (intentionally or otherwise) additional buoyancy, or the use of equipment with additional weight (such as tool belts) will likely alter the performance of the PFD. Users, owners and employers need to ensure that this is taken into account when selecting a PFD. Similarly, PFDs may not perform as well in extremes of temperature, although fully approved under this part of ISO 12402. PFDs may also be affected by other conditions of use, such as chemical exposure and welding, and may require additional protection to meet the specific requirements of use. If the user intends taking a PFD into such conditions, she/he has to be assured that the PFD will not be adversely affected. This part of ISO 12402 also allows a PFD to be an integral part of a safety harness designed to conform to ISO 12401, or an integral part of a garment with other uses, for example to provide thermal protection during immersion, in which case the complete assembly as used is required to conform to this part of ISO 12402.

In compiling the attributes required of a PFD, consideration has also been given to the potential length of service that the user might expect. Whilst a PFD needs to be of substantial construction and material, its potential length of service often depends on the conditions of use and storage, which are the responsibility of the owner, user and/or employer. Furthermore, whilst the performance tests included are believed to assess relevant aspects of performance in real-life use, they do not accurately simulate all conditions of this. For example, the fact that a device passes the self-righting tests in swimming attire, as described herein, does not guarantee that it will self-right an unconscious user wearing waterproof clothing; neither can it be expected to completely protect the airway of an unconscious person in rough water. Waterproof clothing can trap air and further impede the self-righting action of a lifejacket.

It is essential that owners, users and employers choose those PFDs that meet the correct standards for the circumstances in which they will be used. Manufacturers and those selling PFDs have to make clear to prospective purchasers the product properties, alternative choices and the limitations to normal use, prior to the purchase.

Similarly, those framing legislation regarding the use of these garments should consider carefully which class and performance levels are most appropriate for the foreseeable conditions of use, allowing for the higher risk circumstances. These higher risk circumstances should account for the highest probabilities of occurrence of accidental immersion and the expected consequences in such emergencies. More information on the selection and application is given in ISO 12402-10.

Personal flotation devices —

Part 9:
Test methods

1 Scope

This part of ISO 12402 specifies the test methods for personal flotation devices.

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 139:2005, *Textiles — Standard atmospheres for conditioning and testing*

ISO 2768-1, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 3386-1:1986, *Polymeric materials, cellular flexible — Determination of stress-strain characteristics in compression — Part 1: Low-density materials*

ISO 12401:2004, *Small craft — Deck safety harness and safety line for use on recreational craft — Safety requirements and test methods*

ISO 12402-1, *Personal flotation devices — Part 1: Lifejackets for seagoing ships — Safety requirements*

ISO 12402-2:2006, *Personal flotation devices — Part 2: Lifejackets, performance level 275 — Safety requirements*

ISO 12402-3:2006, *Personal flotation devices — Part 3: Lifejackets, performance level 150 — Safety requirements*

ISO 12402-4:2006, *Personal flotation devices — Part 4: Lifejackets, performance level 100 — Safety requirements*

ISO 12402-5:2006, *Personal flotation devices — Part 5: Buoyancy aids (level 50) — Safety requirements*

ISO 12402-6, *Personal flotation devices — Part 6: Special purpose lifejackets and buoyancy aids — Safety requirements and additional test methods*[1)]

ISO 12402-7:—[1)], *Personal flotation devices — Part 7: Materials and components — Safety requirements and test methods*

1) To be published.

ISO 12402-8:2006, *Personal flotation devices — Part 8: Accessories — Safety requirements and test methods*

ISO 12402-10, *Personal flotation devices — Part 10: Selection and application of personal flotation devices and other relevant devices*

ASTM D471-98:1999, *Standard test method for rubber property — Effect of liquids*

International Convention for the Safety of Life of Sea (SOLAS), 1974, as amended, International Maritime Organization[2)]

3 Terms and definitions

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

3.1
personal flotation device
PFD
garment or device which, when correctly worn and used in water, will provide the user with a specific amount of buoyancy which will increase the likelihood of survival

3.2
inherently buoyant material
material which is permanently less dense than water

3.3
automatically operating PFD
PFD in which buoyancy is provided by permanent means (inherently buoyant material) or by suitable means (gas inflation) effected by a system which automatically activates upon immersion and which, except for the inspection and rearming of inflatable types, when correctly donned requires no further action by the user

3.4
automatically inflated PFD
PFD in which inflation is effected as a result of immersion without the user carrying out any action at the time of immersion

3.5
manually inflated PFD
PFD in which inflation is effected as a result of the user operating a mechanism

3.6
orally inflated PFD
PFD inflated by mouth to produce buoyancy

3.7
PFD with secondary donning
PFD for which additional donning or adjustment is needed to place the PFD in its functioning position from the position it is normally worn

NOTE Pouch-type devices are examples of the type of PFDs which usually require such additional positioning.

3.8
vest-type PFD
PFD covering the upper trunk of the user like a vest

2) IMO is an institution with domicile in London issuing regulations which are then published as laws by the member states.

3.9
yoke-type PFD
PFD in a style worn around the back of the neck and secured by a waist strap

3.10
emergency light
device which emits light so as to increase the chances of a user being located

3.11
multi-chamber buoyancy system
system that divides the buoyancy provided by an inflatable lifejacket into two or more separate compartments, such that if mechanical damage occurs to one, others can still operate and provide buoyancy so as to aid the user when immersed

3.12
deck safety harness and safety line
device that allows a user to be securely attached to a strong point on a vessel or on shore, so as to prevent him from falling into the water, or, if he does fall into the water, to prevent him from being separated from the vessel or shore

3.13
buddy line
length of cord which can be tied or otherwise fixed to another person or to that person's PFD or other objects, so as to keep a user in the vicinity of that person or object with a view to making location and thus rescue easier

3.14
lifting loop
device which facilitates manual recovery of a person from water

3.15
sprayhood
cover brought or placed in front of the airways of a user in order to reduce or eliminate the splashing of water from waves or the like onto the airways and thereby to promote the survival of the user in rough water conditions

3.16
protective cover
cover that is normally in place over the functional elements of a PFD in order to protect them from physical damage, or snagging on external objects

NOTE 1 The protective cover may be designed to provide additional properties, i.e. to make the PFDs suitable for use when the subject is exposed to additional hazards, e.g. significant abrasion, molten metal splash, flame and fire.

NOTE 2 The inflatable chamber of an inflatable PFD is an example of a functional element.

3.17
overpressure relief valve
valve which may be used in an inflatable system to avoid the likelihood of destruction caused by overpressure

3.18
whistle
device which, when blown by mouth, produces an audible sound which can aid in the location of the user

3.19
hybrid-type PFD
PFD of combined buoyancy types, i.e. inherent and inflatable

4 Classification of personal flotation devices

An overview of this classification is given in Annex A for information.

5 Test methods

5.1 General

Unless otherwise specified, a new sample of the PFD to be tested may be used for each of the tests.

When material and components of PFDs specified in ISO 12402-7 are conditioned as specified therein and successfully tested according to this part of ISO 12402, they can be assumed to meet the requirements of ISO 12402-7 for the PFD design test.

A combination of PFD and accessories in accordance with ISO 12402-8 shall not impair the performance of either item. This shall be proved during the test required for both PFD and accessories. If necessary, the test sequence shall be arranged accordingly.

The human subject performance tests shall be witnessed by a test panel of at least 2 experts familiar with testing and the products specified in the relevant parts of ISO 12402.

The human subject performance tests shall be carried out under the direction of a test house's test panel that is experienced in these specific test procedures. These tests shall be observed by at least 2 experienced observers from the panel and repeated with 3 experienced observers from the panel if there is any question about the performance observed. An observer is to be qualified by having expertise in observing (or conducting under the supervision of a qualified observer) the specific test on at least 3 occasions.

NOTE 1 Specific test means, for instance, that experience with stability testing would not qualify for self-righting testing or that experience with self-righting testing of inherently buoyant PFDs would not qualify as experience with similar testing of inflatable PFDs.

NOTE 2 It is recommended that the test panel have at least one member of the test house regularly participating in experience exchanges and round robin tests.

All tests according to 5.5 shall be carried out after submitting the samples to the temperature cycling test (see 5.5.3) and the rotating shock bin test (see 5.5.2).

5.2 Sampling and conditioning

5.2.1 Sampling

At least one example of each size of the device to be tested shall be provided.

5.2.2 Conditioning

Prior to testing, the samples shall be conditioned for (24 $\pm$ 0,1) h under the appropriate standard atmosphere as defined in ISO 139 according to the specific fabric used for the PFD.

If spelled out to be tested under wet conditions, the sample shall be soaked for at least 5 min in fresh water, or as specified by the test procedure itself.

5.3 Criteria for passing and failure

All required samples shall pass all tests specified in 5.5 for the entire device to meet the requirements of the relevant parts of ISO 12402. Due to the high variability between human subjects and the difficulty in assessing some subjective measures, for tests according to 5.6 a test subject may be disqualified if demonstrated not to perform in accordance with this standard when tested in a reference vest as described in Annex B, C or D.

When a reference vest is used, the test report shall state the model of reference vest(s). Whenever a subject is disqualified from this test, another two subjects with similar weight, height and anatomic build shall be subjected to the same test and before the same test panel. If these additional tests are still not clearly passed in accordance with this standard and the part of ISO 12402 applicable to the performance level of device, the device shall be deemed to have failed.

5.4 Magnetic properties testing

Place a direct-reading magnetic compass in an undisturbed magnetic area (i.e. an area in which magnetic items and d.c. electrical cables are not continually moved or switched). Check the compass to ensure that it has negligible pivot friction. This can be done by deflecting the compass card 10° by means of a magnet and then removing the deflecting force, when the card should return to within 0,5° of its original position.

Present the metal components (with any hooks closed) individually to the compass on an approximately east-to-west line, to a position where the nearest point of the component is (300 ± 10) mm horizontally from the center of the compass. Lightly tap the compass to eliminate the effect of friction. Record the angle, in degrees, of any deflection of the compass from its position before the metal components were brought near the compass.

5.5 Mechanical properties tests

5.5.1 Horizontal and vertical load tests

5.5.1.1 Principles

The PFD shall be subject to tension via its integral structure, such as waist belt or harness arrangement, by means of a specified load. The tests shall be carried out in the following order and be applied to the same PFD sample:

a) horizontal load test wet;

b) vertical load test wet.

NOTE Test houses may use other test arrangements as described in 5.5.1.3, i.e. by means of a hydraulic jig, if the load maintained and the same accuracy of results can be achieved.

5.5.1.2 Apparatus

The apparatus consists of a horizontally suspended upper cylinder, of diameter (50 ± 5) mm for PFD user masses less than 40 kg, or of diameter (125 ± 10) mm for PFD user masses of 40 kg and above, to which the PFD is fitted. The length of the test cylinder shall be sufficient to accommodate the full width of the portion of the PFD under test.

For the horizontal load test shown in Figures 2 and 4, an additional lower test cylinder of similar size to the upper cylinder shall be placed in the PFD in the position indicated. The axes of the upper and lower cylinders shall be regarded as the datum positions A1-A2 and B1-B2, respectively, shown in Figures 2 and 4.

For the horizontal load test shown in Figures 2 and 4, a pre-load is required. The total pre-load shall be (20 ± 2) N.

For the vertical load tests shown in Figures 3 and 5, the lower apparatus shall have the dimensions as indicated in Figures 6 and 7. The diameter of the tube shown in Figure 7 shall be (50 ± 5) mm for PFD user masses less than 40 kg and (125 ± 10) mm for user masses of 40 kg and above.

For these vertical load tests, a test mass shall be applied to the attachment positions indicated by means of webbing (25 ± 5) mm in width.

5.5.1.3 Procedure

5.5.1.3.1 General

The webbing or movable part of the assembly shall be marked at each point of adjustment prior to application of each test load. This includes tie tapes, draw cords, and lacing, as well as webbing-hardware adjustments.

5.5.1.3.2 Horizontal load test

The PFD shall be fitted (if inflated by its primary means of inflation (30 ± 5) min prior the test being carried out) to the upper test cylinder, in the manner shown in Figure 2 for halter types or Figure 4 for vest types. If inflatable, it shall be tested both when uninflated and when inflated by its primary means of inflation. The PFD shall be attached to the cylinders such that all adjustment devices are tested. The position of the webbing relative to the adjustment devices it passes through shall be marked.

The lower test cylinder shall be fixed in the appropriate positions shown in Figures 2 and 4. The specified pre-load shall be added and the test arrangement shall be adjusted such that the axes A_1-A_2 and B_1-B_2 of the upper and lower test cylinders are substantially parallel and horizontal.

The additional test load shall be applied steadily until the PFD is hanging freely. The load shall be maintained for the specified period.

The PFD shall be examined for any failures resulting in functional damage of the PFD.

5.5.1.3.3 Vertical load test

The PFD shall be fitted to the upper test cylinder, in the manner shown in Figure 3 for halter types or Figure 5 for vest types. If inflatable, it shall be tested both when uninflated and when inflated by its primary means of inflation.

For halter types, adjust the harness to fit the test body according to Figure 6. For vest types, fasten the PFD in such a way that any adjustment devices are tested. Mark the position of the webbing relative to any adjustment devices it passes through.

Attach the load suspension cord to the PFD in the appropriate positions shown in Figures 3 and 5. Apply the test load steadily without jerking. Maintain the test load for the specified period. Remove the test load and examine the PFD for any resultant failures. Measure any adjustment device slippage.

5.5.1.4 Lifting loop test

All PFDs equipped with a lifting loop shall be soaked in fresh water for a period of 5 min. The PFD shall then be fitted to the appropriate test dummy according to the manufacturer's donning and adjustment instructions. If inflatable, the lifejacket shall be inflated prior to load application.

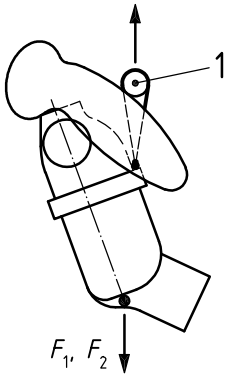
Then apply the loads F_1 or F_2 (see Figure 1) to the lower attachment point of the dummy in accordance with ISO 12401:2004, 5.2.2.1. Lift the dummy by means of a cylinder of (50 ± 5) mm in diameter, which is put through the loop without jerking until it is suspended freely.

Maintain the load for (1 ± 0,1) min.

See also 5.5 in the relevant parts of ISO 12402.

5.5.1.5 Buddy line test

If a buddy line is attached to a PFD, a load of 750 N shall be applied for (1,0 ± 0,1) min perpendicular to the PFD, whilst the PFD is fitted to a torso in accordance with ISO 12401. No damage shall occur to the buddy line or to the PFD.



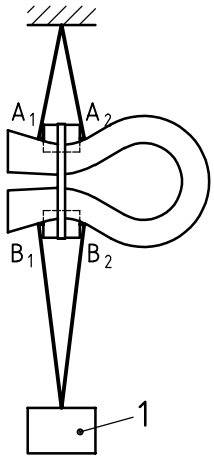
Key

F_1 load for adult size (according to 5.5 in the relevant part of ISO 12402)

F_2 load for child size (according to 5.5 in the relevant part of ISO 12402)

1 test load

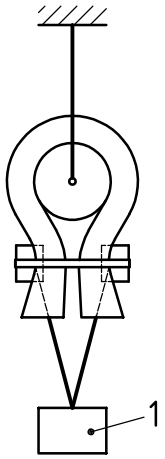
Figure 1 — Test dummy



Key

1 test load

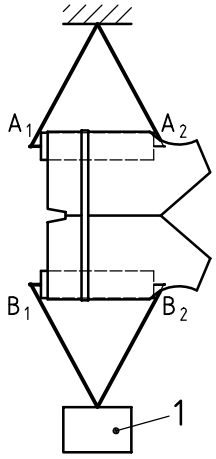
Figure 2 — Horizontal load test of yoke-type PFD



Key

1 test load

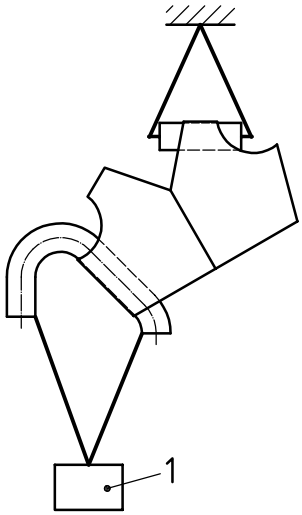
Figure 3 — Vertical load test of yoke-type PFD



Key

1 test load

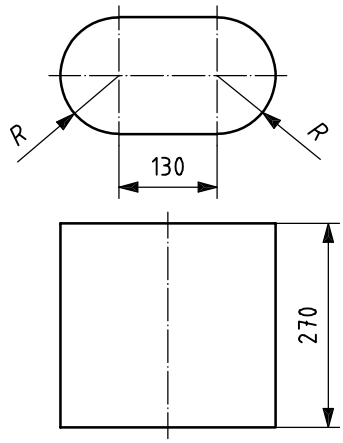
Figure 4 — Horizontal load test of vest-type PFD



Key
1 test load

Figure 5 — Vertical test of vest-type PFD

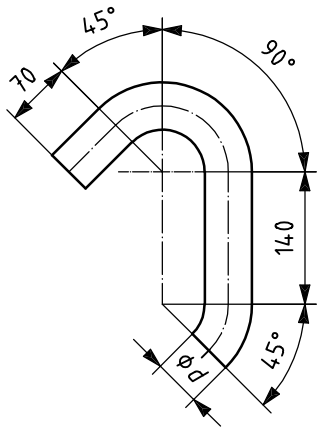
Dimensions in millimetres



Key
R = 155 mm

Figure 6 — Body for vertical load test (general tolerances ISO 2768-1, v)

Dimensions in millimetres



Key
∅ = (125 ± 10) mm for adult size
∅ = (50 ± 10) mm for child size

Figure 7 — Bent tube for vertical load test (general tolerances ISO 2768-1, v)

5.5.2 Rotating shock bin test method

5.5.2.1 Principle

The PFD shall provide a minimum resistance against wear and tear.

5.5.2.2 Apparatus

The equipment used shall be that shown in Figure 8, and consists of a box made from plywood board, the inside surface of which shall be coated with a hard plastic laminate or similar. The bearing of the bin shall be in the center of its mass, as shown in Figure 8, and permit the bin to be rotated freely.

5.5.2.3 Procedure

The PFD shall be exposed to this test in the condition “ready for use”, i.e. unpacked and un-inflated, if inflatable, buckles closed but not tightened or wrapped around.

The test specimen shall be placed in the bin through a flush panel in one of its faces, which shall then be closed and secured. The bin shall then be rotated for a total of 150 revolutions at a steady rate of 6 rev/min.

On completion of the rotations, the specimen shall be removed. The device, if inflatable, shall be inflated for (5,0 ± 0,1) min then examined for damage and checked for leaks under water. Perform the functional test according to the relevant performance level if damage is detected.

Dimensions in millimetres

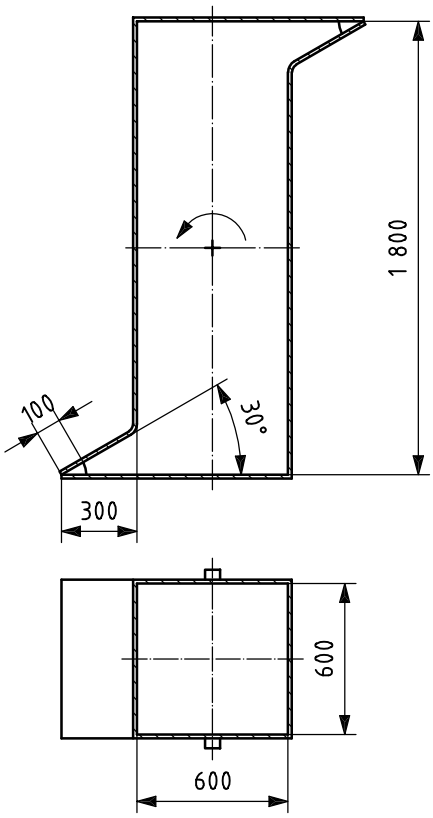


Figure 8 — Design of rotating shock bin apparatus

5.5.3 Temperature cycling test

5.5.3.1 For inherently buoyant PFDs, six samples shall be alternately subjected for 8 h to surrounding temperatures of (− 30 ± 2) °C and (+ 65 ± 2) °C. These alternating cycles need not follow immediately after each other and the following procedure, repeated for 10 cycles, is acceptable.

An 8 h cycle at (+ 65 ± 2) °C is to be completed in one day. The samples are to be removed from the warm chamber that same day and left exposed under ordinary room conditions until the next day.

An 8 h cycle at (− 30 ± 2) °C is to be completed the next day. The samples are to be removed from the cold chamber that same day and left exposed under ordinary room conditions until the next day.

Two of the samples shall be cut open and shall not show any sign of internal change of structure.

Four of the samples shall be used for the water absorption test according to 5.5.5. Two of these samples shall be so tested after they have also been subjected to the oil and water resistance tests (5.5.4).

5.5.3.2 If inflatable, two PFDs shall be subjected to the temperature cycling test in the uninflated condition and shall then be externally examined. The inflatable PFDs shall show no sign of damage such as shrinking, cracking, swelling, dissolution or change of mechanical qualities. The automatic and manual inflation systems shall each be tested immediately after each temperature cycling test as follows.

a) After the high temperature cycle at (+ 65 ± 2) °C, the two inflatable PFDs are removed from the warm chamber. One shall be activated using the automatic inflation system by placing it in sea water at a temperature of (+ 30 ± 2) °C and the other shall be activated using the manual inflation system.

b) After the low temperature cycle at (– 30 ± 2) °C, the two inflatable PFDs are removed from the cold chamber. One shall be activated using the automatic inflation system by placing it in sea water at a temperature of – 1 °C and the other shall be activated using the manual inflation system.

5.5.4 Oil and water resistance tests

5.5.4.1 General

The PFD (if inflatable, in the un-inflated condition) shall be immersed completely in oil and artificial sea water. Between immersions, the PFD shall be cleaned and left to dry for (17,0 ± 0,1) h according to the instructions given in the information supplied by the manufacturer.

If the PFD is automatically inflated, the mechanism producing automatic activation shall be disabled prior to this test, and it shall be inflated using the manual mechanism on completion.

5.5.4.2 Sea water resistance test

The PFD shall be immersed in a tank of artificial sea water (4,5 % NaCl) horizontally (300 ± 30) mm below the surface for a period of 72 h at normal room temperature.

The PFD shall be examined for any failures resulting in functional damage of the PFD.

5.5.4.3 Oil resistance test

A sample of the device, with any automatic inflation means disabled, is to be subject to a series of three separate 5 min immersion periods of total submergence in fuel B according to ASTM D471-98:1999, with a 30 min drying period between submersions. After the last submergence period, the sample is to be removed from the liquid and the excess liquid allowed to run off for 5 min. The sample, if inflatable, is to be inflated by the primary means of inflation in accordance with the design inflation range.

The PFD shall be examined for any failures resulting in functional damage of the PFD.

5.5.5 Water absorption test

The test is applicable to devices with inherently buoyant material, insofar as material samples have not been exposed when tested according to ISO 12402-7.

A set of two samples of the PFD as delivered, two samples having been exposed to the temperature cycling test according to 5.5.3 and two samples having been exposed according to 5.5.3 and 5.5.4 shall be placed in a tank of fresh water at a depth of 1 250 mm for seven days. Changes of dimensions shall be reported. The minimum buoyancy shall be not less than required in 5.3.4.2 of ISO 12402-2:2006 to ISO 12402-5:2006.

The changes of buoyancy after one day and seven days shall be reported.

5.5.6 Over-pressure test

The inflatable buoyancy chambers shall be capable of withstanding an internal over-pressure at ambient temperature. All chambers of a PFD shall be inflated to 4,0 kPa using the oral method of inflation. After inflation the relief valves shall be disabled and a fully charged gas cylinder (but not multiple cylinders as would be present on SOLAS dual-chamber PFDs) according to manufacturer's instructions shall be fitted to the same inflation device and the device actuated. The device shall be set aside for 10 min. The pressure shall then be increased by 20 % in all chambers. All fully charged gas cylinders used in this test shall be sized according to the markings on the PFD. Chamber integrity and leakage shall be checked after 5 min by functional tests.

If the PFD is of multi-chamber design, the test procedure shall continue. With one buoyancy chamber inflated (at 4,0 kPa), the operating head on the opposite buoyancy chamber shall be fired manually, using a fully charged gas cylinder according to the manufacturer's instructions. The operation of the relief valves shall be noted to ensure that the excess pressure is relieved. Chamber integrity and leakage shall be checked after 5 min by functional tests.

5.5.7 Air retention test

One inflation chamber of a PFD is filled with air until air escapes from the over-pressure valve or – if the PFD does not have an over-pressure valve – until its maximum design pressure, to the same pressure as achieved when inflated with the primary means or 13,8 kPa, whichever is greater, is reached. The buoyancy of the inflation chamber shall be measured according to 5.5.9.

The measurement shall be started when the pressure-relief valve has closed. After 12 h, the buoyancy of the inflation chamber shall be measured again and compared to the initial buoyancy.

This test is to be repeated as many times as necessary to test a different chamber until each chamber has been tested in this manner.

5.5.8 Colour

The colour of the exposed portions (excluding components such as webbing, zippers and other fittings) of the lifejacket when deployed in the normal flotation position shall be in accordance with ISO 12402-7:—[3)], 4.3.3.

5.5.9 Measurement of buoyancy of the whole device

5.5.9.1 Principle

The buoyancy of the device shall be measured using Archimedes' principle of weighing the device in air and water, as specified below.

The two inflatable PFDs subjected to the temperature cycling test according to 5.5.3.2 shall be used for the buoyancy test.

For inherently buoyant PFDs, the buoyancy of the two PFDs shall be measured upon initial stabilisation (buoyancy without entrapped air) and after 24 h complete submersion.

For inflatable and multi-chamber devices, the test shall be repeated according to the number of inflatable chambers and inflatable systems under deflated condition 5.7 of ISO 12402-8:2006. Every possible combination of chambers and inflation systems shall be tested with one of the chambers in the deflated condition.

The chamber shall be fitted with the correct gas cylinder.

See also ISO 12402-8:2006, 5.7.

5.5.9.2 Apparatus

The standard equipment required consists of a weighted cage, whose mass in kilograms is greater than 1,1 times the expected buoyancy value.

Weighing takes place in a tank of water, deep enough to accommodate the device at a depth of 100 mm to 150 mm below the surface, and with a calibrated load cell or balance supporting it.

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3) To be published.

5.5.9.3 Procedure

If the PFD contains inflatable buoyancy, it shall be inflated through the oral inflation tube to the pressure reached by the primary means of inflation (or 1,4 kPa ± 0,1 kPa, if orally inflated). The PFD shall then be enclosed in the cage attached to the weight.

The cage shall be suspended in fresh water at a temperature of (20 ± 5) °C from the load cell so that the PFD is submerged at 100 mm to 150 mm below the surface. The immersed weight shall be recorded as A.

The assembly shall remain immersed for (24,0 ± 0,5) h, after which time the weight shall again be recorded as B.

The PFD shall finally be removed from the cage. The weight plus the cage shall again be immersed and the result again recorded as C.

5.5.9.4 Results

The initial buoyancy is obtained by deducting A from C. The final buoyancy is obtained by deducting B from C. The buoyancy lost during immersion is obtained by deducting the final buoyancy from the initial buoyancy.

The water temperature, air temperature and atmospheric pressure shall be recorded at the start of each test and then after 24 h on completion of each test and the buoyancies shall be corrected to the values of standard temperature and pressure conditions.

5.5.10 Inflation test

5.5.10.1 General

The inflation can be carried out using normal air.

5.5.10.2 Inflated PFDs

5.5.10.2.1 The inflation test shall be carried out twice: once at (– 5 ± 1) °C and once at (+ 30 ± 1) °C.

5.5.10.2.2 Inflated PFDs shall achieve sufficient buoyancy to conform to the relevant part of ISO 12402, including correct distribution through the chambers, within the time required in the relevant part of ISO 12402 after firing the inflation mechanism.

5.5.10.2.3 The PFD shall be placed securely on a test frame. A force shall be applied to the pull toggle in the correct direction to fire the operating head. Starting at 20 N, the head shall not fire until the force is less than 75 N.

5.5.10.2.4 The inflatable buoyancy chambers shall be capable of withstanding an internal over-pressure. All chambers of a PFD shall be inflated to 40 kPa using the oral method of inflation. After inflation the relief valves, if fitted, shall be disabled and a fully charged gas cylinder (but not multiple cylinders used for a dual-chamber PFD) according to manufacturer's instructions shall be fitted to the same inflation device and the device actuated. The device shall be set aside for 10 min. The chamber pressure shall then be increased by 20 %. All fully charged gas cylinders used in this test shall be sized according to the marking on the PFD. Chamber integrity and leakage shall be checked after 5 min by functional tests.

The pressure shall then be increased to 120 % of the pressure achieved before by the inflation and kept for 5 min. The buoyancy chambers shall then be examined for visible signs of damage.

5.5.10.2.5 Automatically inflated PFDs shall first be conditioned by exposing them for (5,0 ± 0,1) h to an air temperature of (0 ± 1) °C. Then they shall be submersed rapidly until the operating head is at a depth of (300 ± 50) mm beneath the surface of fresh water at a temperature of 0 °C.

The time from immersion until initiation of inflation in automatic mode shall be reported. It shall not exceed 5 s.

5.5.11 Test of the resistance to inadvertent inflation

5.5.11.1 Principle

The resistance of an automatic inflation device to inadvertent operation shall be assessed by exposing the entire PFD to sprays of water for a fixed period.

After the test, it is necessary to examine whether the automatic device works.

5.5.11.2 Apparatus

The PFD shall be fitted correctly to a free-standing rotating manikin or equivalent type of test form of adult size, with a minimum shoulder height of 1 500 mm. The PFD shall be deployed in the mode in which it is used ready for use, but not deployed as used in the water (i.e. if it is equipped with a cover which is normally used closed, then the cover shall be closed for the test). See Figure 9.

Two spray nozzles shall be installed so as to spray fresh water onto the PFD, as shown in Figure 9. One shall be positioned 500 mm above the highest point of the PFD, be oriented at an angle of 15° from the vertical centerline of the manikin and be centered on the inflation system. The other nozzle shall be installed horizontally at a distance of 500 mm, be centered on the inflation system, and oriented directly at the PFD. These nozzles shall have a spray cone of 30°, each orifice being $(1{,}5 \pm 0{,}1)$ mm in diameter, and the total area of orifices on each shall be (50 ± 5) mm^2, the orifices being evenly spread over the spray nozzle area.

The air temperature shall be (20 ± 3) °C, and water shall be supplied to the sprays at a flow of 600 l/h, and a temperature of (19 ± 1) °C.

5.5.11.3 Procedure

The sprays shall be turned on, and the PFD exposed to the following series of spray exposures by turning the test apparatus according to Figure 9:

a) 10 min with high spray on the front;

b) 10 min with high spray on the left side;

c) 10 min with high spray on the back;

d) 10 min with high spray on the right side.

During exposures a), b) and d), the horizontal spray shall be applied for 10 periods of 3 s each to the front, left or right sides (but not the back), as with the high spray.

Dimensions in millimetres

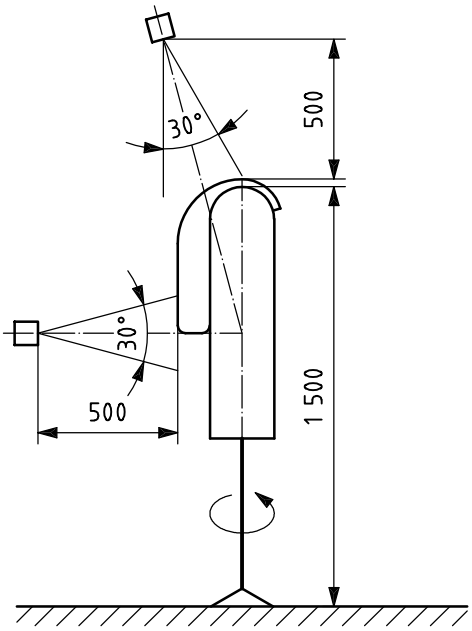


Figure 9 — Test apparatus for automatic inflation devices

5.5.12 Test of the resistance to burning

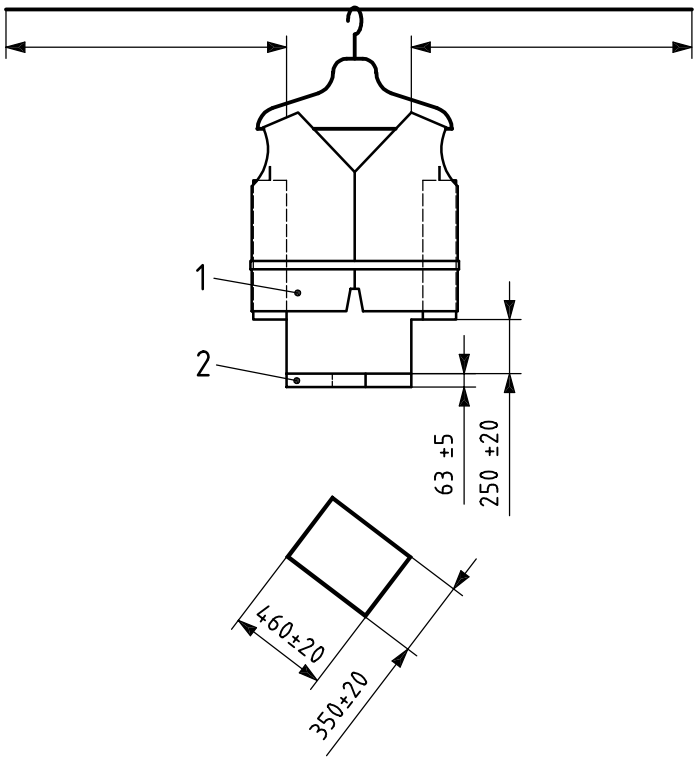
5.5.12.1 Principle

This test is to demonstrate that the PFD does not create a greater hazard to the user when exposed to flame than if the user were not wearing any PFD. The premise is that a person will sustain injury if subjected to a fire as specified herein for more than 2 s, and a PFD shall not add fuel to or intensify such an exposure and shall remain useful after the exposure.

5.5.12.2 Apparatus

The test pan shall be (460 ± 20) mm $\times$ (350 ± 20) mm $\times$ (63 ± 5) mm. See Figure 10. The test shall be conducted in a large, essentially draft-free enclosed area.

Dimensions in millimetres



Key

1 PFD

2 test pan

Figure 10 — Test arrangement

5.5.12.3 Procedure

10 mm of water is to be put in the bottom of the test pan, followed by enough petrol to make a minimum total depth of 40 mm. The petrol is to be ignited and allowed to burn freely for 30 s before the device is inserted.

The upright device is to be passed through the flames in a forward, vertical, free-hanging position, with the bottom of the device (250 ± 20) mm above the top edge of the test pan. Loose parts, e.g. crotch straps, are to be secured above the lower edge of the bottom of the device. The sample is to be exposed to the flame for 2 s, starting as soon as the leading edge of the sample is touched by the flames and stopping as the trailing edge leaves the flames.

Except for lifejackets according to ISO 12402-1, if the device is burning upon emergence from the flames, 6 s shall elapse before extinguishing the flames. For lifejackets according to ISO 12402-1, if the device is burning upon emergence from the flames, the time until the device stops burning shall be recorded.

Gas cylinders shall be removed from inflatable PFDs for the duration of this test.

Following exposure to the flames, the device shall be subjected to the horizontal load test called for by the performance level of PFD being tested, except that the test loads shall be 75 % of those specified.

5.5.12.4 Results

At the conclusion of the burning test, the device shall be subjected to the water entry test, and either the self-righting or flotation stability test, as appropriate to the performance level of the PFD being tested, utilizing one test participant having the maximum chest size or weight, as appropriate, for which the device is intended.

5.6 Human subject performance tests

5.6.1 Test subjects

5.6.1.1 General

The PFD according to the relevant part of ISO 12402 shall be tested using subjects in front of the test panel described in 5.1. Tests shall be conducted in a swimming pool containing fresh water, treated as necessary for hygienic purposes.

Donning of PFDs shall be tested on various sizes of adult, wearing both ordinary and heavy clothing. A PFD designed to be worn inside-out shall be tested in all configurations.

Ordinary clothing is defined as follows:

— underwear (short sleeved, short legged);

— shirt (long sleeved);

— trousers (not woollen);

— athletics shoes, if the device is required to be donned over the foot and leg.

Heavy clothing is defined as ordinary clothing with the addition of a woollen sweater and woollen overcoat.

Test subjects shall be generally informed of the methods and intent of the in-water performance tests, but should have no knowledge of the specific PFD being tested. The subjects shall be in suitable health to physically perform the tests. The principles of the Declaration of Helsinki as amended shall be considered in so far as applicable. The test shall have been passed if all results of the human subject performance tests are positive.

The tests may be modified for child test subjects under 12 years of age who are not water adapted, so as to ensure their safety and co-operation. When assessing such children's sizes, the panel can make greater use of subjective indicators, as self-righting and jumping can be hazardous and more subjective when applied to small children. The position in the water and support afforded can be useful indicators.

Reference testing with child manikins shall be done according to 5.6.9.

5.6.1.2 Subject requirements for adults

PFDs shall be tested using at least 12 subjects if the device is sized to accommodate a range of chest sizes in excess of 400 mm or a body mass range greater than 30 kg. If the manufacturer offers different sizes, at least five subjects for lifejackets and special purpose devices and three subjects for buoyancy aids shall be used to test each size range which does not exceed 150 mm chest circumference or 20 kg body mass. PFD designs having size ranges between these limits shall be tested on a proportionate number of subjects.

The test shall be carried out with able-bodied persons according to Table 1. The marked weight and/or height and chest size, if stated, on the PFD shall be taken into account when selecting test subjects.

Table 1 — Adult test subjects

Height category mm	Body mass kg							
	40 to 42	> 42 to 60	> 60 to 70	> 70 to 80	> 80 to 100	> 100 to 110	> 110 to 120	> 120
< 1 500	1	X	X	X	—	—	—	—
1 500 to 1 600	X	1	1	X	X	—	—	—
> 1 600 to 1 700	—	X	X	1	X	X	—	—
> 1 700 to 1 800	—	—	X	X	1	X	X	X
> 1 800 to 1 900	—	—	X	X	X	1	1	X
> 1 900	—	—	—	—	X	X	X	1

NOTE 1 Between one third and one half of test subjects shall be females, including at least one per height category but excluding the upper height category.

NOTE 2 At least one male and one female shall be from the lowest and highest mass groups appropriate to the PFD.

NOTE 3 At least one subject shall be selected per cell which is appropriate to the PFD and marked with a “1”.

NOTE 4 Enough additional subjects shall be selected from cells marked ‘X’ to total the required number of test subjects for the size range of PFD, with no more than one subject per cell. A uniform distribution across mass groups shall be maintained.

NOTE 5 The test subject size selection shall be adjusted for the lowest mass group to test at least one subject within 2 kg of the lowest size for which the PFD is to be certified. Subjects of less than 40 kg may be shorter than 1 400 mm if required. One subject shall be tested for each 4 kg below 40 kg.

Each test subject shall be made familiar with each of the tests, particularly the requirements regarding relaxing and exhaling in the face-down position.

Only good swimmers shall be used, since the ability to relax in the water is rarely otherwise obtained.

To verify that the test subjects used represent a valid cross-section of the adult population for testing a lifejacket according to ISO 12402-1, the average face-up righting time for the group of test subjects shall be at least 2,2 s when tested using the reference vest specified in Annex B and the leg release method according to 5.6.6.3 a).

5.6.1.3 Subject requirements for children

Test subjects shall be selected to fully represent the range of sizes for which the device is to be approved. Devices for smaller children shall be tested on children as small as approximately 760 mm tall and 9 kg mass. At least six test subjects shall be used for each 380 mm and 16 kg of size range according to Table 2.

Water tests using children shall avoid causing distress or risk to the child. Consideration shall be taken of their age and ability.

Table 2 — Child test subjects

Height category cm	Body mass kg											
	9 to 12	> 12 to 14	> 14 to 17	> 17 to 20	> 20 to 22	> 22 to 25	> 25 to 28	> 28 to 30	> 30 to 33	> 33 to 36	> 36 to 38	> 38 to 41
76 to 83	1	X	—	—	—	—	—	—	—	—	—	—
79 to 105	X	1	X	X	X	—	—	—	—	—	—	—
90 to 118	—	—	X	X	1	X	—	—	—	—	—	—
102 to 130	—	—	—	—	X	X	X	X	—	—	—	—
112 to 135	—	—	—	—	—	—	X	X	X	—	—	—
122 to 150	—	—	—	—	—	—	—	—	1	1	X	X
145 to 165	—	—	—	—	—	—	—	—	—	—	X	1

NOTE 1 Between one third and one half of the subjects shall be females, including at least 1 per height category but excluding the upper height category.

NOTE 2 At least one subject shall be selected per cell which is appropriate to the PFD and marked with a “1”.

NOTE 3 Enough additional subjects shall be selected from cells marked ‘X’ to total the required number of test subjects for the size range of PFD. A uniform distribution across mass groups shall be maintained.

When conducting water performance tests, child-size PFDs shall meet the requirements for their minimum buoyancy. The range of sizes for child-size PFDs shall be considered based on the test results. Devices shall be sized by height or by height and body mass.

5.6.1.4 In-water weight

This test is only to be carried out on subjects for adult’s lifejackets.

The in-water weight of each test subject is to be measured to ensure an adequate minimum acceptable range of representative subjects. The in-water weight of each test subject of 40 kg or more is taken with the tip of the chin and bottom of the ear lobes touching the water at the bottom of the normal breathing cycle. The in-water weight is the highest repeated value out of 10 readings or the third highest value if none is repeated.

5.6.1.5 Sex and dress

Subjects shall include both males and females and no more than two thirds of one sex. See also Table 1. All test subjects shall use only bathing costumes during height, weight, and in-water measurements and for all in-water tests. After being weighed and measured, the subject shall be dressed in ordinary clothing (see 5.6.1.1) to conduct the donning test before becoming familiar with the PFD being tested.

5.6.2 Measurement of freeboard

5.6.2.1 Principle

The freeboard shall be measured as the vertical difference between the water surface and the lowest corner of the mouth.

5.6.2.2 Apparatus

A suitable measuring device is shown in Figure 11. It consists of two floats made of closed-cell foam, connected by a rigid bridge at such a height that a test subject using a PFD in the water has approximately 100 mm clearance between the top of his head and the bridge. On the bridge, one third of the way along from one end, a steel measuring tape roll or drum is to be placed, in such a way that the tape is free to drop below

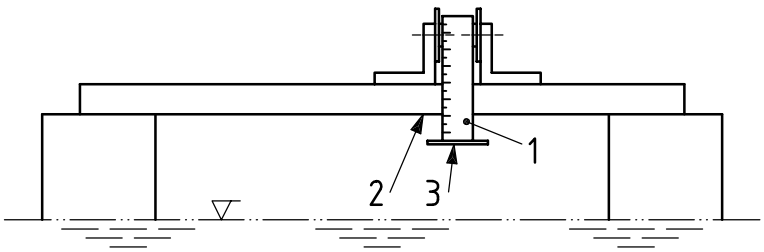
the bridge as shown. This roll or drum shall contain a locking mechanism to maintain a fixed tape protrusion length. At the free end of the tape, a plastic disk of (100 ± 5) mm diameter is fixed in a perpendicular position. There is also a measuring mark made along the bottom edge of the bridge.

5.6.2.3 Procedure

Two measurements of distance shall be made using the measuring device. The first shall be that between the measuring line and the fresh-water surface, which shall be still and calm. The test subject shall then be positioned floating in a relaxed position, inclined backwards, between the two floats of the device. The subject is to be instructed to relax during measurement of the freeboard. The distance between the measuring line and the lowest point of respiration, typically the corner of the mouth, of the subject shall then be measured.

5.6.2.4 Results

The individual freeboard for each subject shall be recorded.



Key

1 tape
2 measuring mark
3 plastic disk

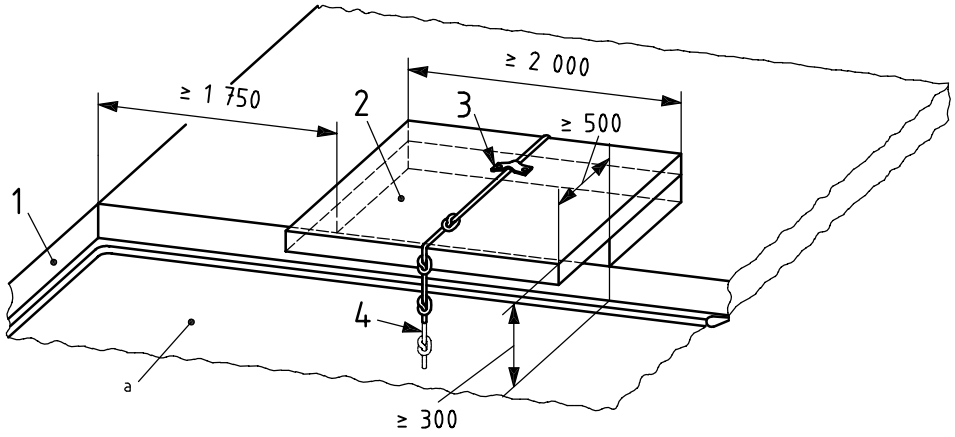
Figure 11 — Device for measuring freeboard

5.6.3 Boarding test

The test shall prove and limit the encumbrance of a PFD on the ability of the wearer to climb out of water under adverse conditions.

All test subjects, without using the PFD, shall attempt to swim 25 m and board a SOLAS liferaft or rigid platform as shown in Figure 12 with its surface 300 mm above the water surface. All test subjects who successfully complete this task shall perform it again using a PFD. At least two thirds of the subjects shall complete the task with and without the PFD.

Dimensions in millimetres



Key

1 pool side
2 platform
3 rope fixing point
4 rope

a Water level.

Figure 12 — Boarding platform

5.6.4 Donning test

5.6.4.1 Principle

PFDs are evaluated for ease of donning to assess their usefulness in an emergency. If the PFD is an integral part of another garment, then this test shall only apply to its donning and doffing for its function as a PFD. Inflatable PFDs shall be tested inflated and uninflated.

5.6.4.2 Procedure

Using ordinary clothing, subjects who are completely unfamiliar with the PFD shall attempt to don the PFD to a snug fit. If the attire customary to the designated purpose of the PFD can have an adverse effect on the test results, the tests shall be repeated with at least one subject wearing such attire. Each subject may have two attempts as follows.

a) For all PFDs, the first attempt shall be with no assistance, guidance or prior demonstration. The PFD, with closures undone and adjusted to fit a mid-sized subject, shall be placed on the deck, face up, in front of the test subject. The instruction provided shall be identical for each subject and shall be equivalent to the following: “PLEASE DON THIS DEVICE QUICKLY AND SECURELY SO YOU CAN ABANDON SHIP.” The attempt shall be timed. Donning is considered complete when the subject has donned and securely adjusted all methods of securing the PFD to the extent needed to meet the in-water performance requirements for the performance level of PFD, including inflation, if needed.

b) For PFDs according to ISO 12402-2 to ISO 12402-6, the second attempt, if necessary, shall be after the test subject has read the instructions printed on the PFD.

c) For lifejackets according to ISO 12402-1, if necessary, the second attempt shall be after the subjects have viewed a demonstration of proper donning of the lifejacket.

For lifejackets according to ISO 12402-1, each subject shall make one additional donning attempt using the procedures specified in a) while using heavy-weather clothing consisting of an arctic parka with hood and warm cotton gloves.

5.6.4.3 Results

All PFDs shall be capable of being completely donned by at least 75 % of persons using ordinary clothing and who are completely unfamiliar with the PFD within a period of 1 min without assistance, guidance or prior demonstration. If less than 75 % of the first group of test subjects are able to don the lifejacket within the 1 min period on the first attempt, a second and third set of test subjects may be used to cumulatively demonstrate meeting the 75 % criterion. If used, the second and third sets of subjects shall meet the same criteria as the first set of subjects.

For PFDs according to ISO 12402-2 to ISO 12402-6, after the subjects have read the instructions printed on the PFD, the PFD shall be capable of being completely donned by all persons without assistance within a period of 1 min.

For lifejackets according to ISO 12402-1, after the subjects have viewed a demonstration of proper donning of the lifejacket, the PFD shall be capable of being completely donned by all persons without assistance within a period of 1 min.

For lifejackets according to ISO 12402-1, using heavy weather clothing, all persons shall be able to correctly don it within a period of 1 min without assistance.

5.6.4.4 Secondary donning

All devices requiring additional action by the user, such as oral inflation or other activities in the way of secondary donning, shall be tested on each subject to demonstrate that they can be accomplished within the prescribed time. The subjects shall prove that the necessary action for secondary donning and inflation can be performed in water and on land within the prescribed time.

5.6.5 Water entry test

5.6.5.1 Principle

PFDs shall be evaluated for their ability to stay on a user when falling or jumping into the water, and to remain in a usable position. The evaluation is intended to cover most unfavourable attitudes of water entry.

The PFD shall withstand any damage when the user jumps from height. The PFD shall be tested according to the designated design. The test shall prove all service conditions, i.e. for a PFD being inflated both automatically and manually, or if of multi-chamber design also with one of the compartments uninflated. The tests shall be repeated as many times as necessary to verify all service conditions.

The subject shall be familiar with jumping from such height.

Without readjusting the PFD, the test subject shall jump vertically into the water, feet first. The test subject shall be allowed to hold on to the PFD or brace arms during water entry to avoid possible injury.

The test subject shall come to rest with the mouth clear of the water by at least the required freeboard.

Any elastic parts used to improve the fit of the garment shall be cut prior to the test.

5.6.5.2 Procedure

5.6.5.2.1 An inflatable PFD shall be donned and inflated by the primary means of inflation. Non-inflatable PFDs shall be donned. The test subject, initially with arms held vertically over the head, shall fall or step into the water, feet first, from a height of $(1\,000\,^{0}_{+500})$ mm. Upon going into the water, the test subject shall relax to simulate a state of utter exhaustion. Water entry in other orientations such as a dive or a feet-first step with arms at sides shall be performed if they are more likely to produce adverse results.

For manual CO_2-inflated PFDs the test shall be repeated after evacuating the inflation chamber and re-inflating it manually once in the water with the appropriate size CO_2-filled cylinder. For automatic CO_2-inflatable PFDs the test shall be repeated on the uninflated device, with the system armed, after evacuating the inflation chamber.

5.6.5.2.2 When testing PFDs according to ISO 12402-2 to ISO 12402-5, the feet-first water entry tests shall be repeated with the subject entering the water from a height of $(3\,000\,^{0}_{+500})$ mm.

5.6.5.2.3 For PFDs according to ISO 12402-1, the test subject shall additionally perform this test by jumping vertically into the water, feet first, from a height of $(4\,500\,^{0}_{+500})$ mm.

5.6.5.3 Results

The average of all subjects' trunk angles shall be at least 30° behind vertical, and each individual subject's angle shall be at least 20° behind vertical. The average of all subjects' face plane (head) angles shall be at least 40° above horizontal, and each individual subject's angle shall be at least 30° above horizontal.

The panel shall examine the PFD and note any damage.

The panel shall observe that the PFD is not dislodged, does not harm the wearer, has not been damaged to endanger its in-water performance, and brings the wearer to the surface in the attitude specified in the applicable part of ISO 12402. When not required to bring the subject to a face-up position, the panel shall observe that the PFD permits the subject to maintain a vertical or backwards inclined attitude without having to carry out any movement other than postural adjustment or small head movements.

5.6.6 Self-righting and stability test

5.6.6.1 Principle

5.6.6.1.1 The tests according to 5.6.6.3 shall demonstrate that a PFD (see 5.6 of ISO 12402-2:2006 to ISO 12402-5:2006) being evaluated provides

a) adequate face-up stability, and associated resistance to being turned face down by waves or other forces, and

b) the intended potential for bringing the user face up in the unlikely event that the user either enters the water face down and unconscious, or becomes unconscious in the water.

These test procedures recognize that different body types present differing resistance to the face-up turning capacity of a PFD, and therefore are intended to evaluate a wide range of the population with as few test subjects as possible.

An inflatable PFD shall be tested inflated by its primary means of inflation. Chambers provided with only oral inflation capability shall be tested inflated to 4 kPa.

Because a tense subject is not representative nor simulates a state of utter exhaustion, the starting time for all righting tests shall not begin until the subject is noted to be in a relaxed position. A relaxed position should be achieved by having the subject relax his body with arms starting perpendicular to the body (end of breaststroke in three stroke tests) and the head going into the water at the same time. If turning starts before the subject has relaxed, the test is invalid and the test is to be repeated. If the PFD is so buoyant that the subject cannot get his/her face down into the water before being righted, the turn is to be counted.

NOTE The amount of air in test subjects' lungs has a profound influence on the test results, and subjects should be instructed accordingly. For a 'normal breath' or 'half breath' the lungs should be near the top of 'tidal volume' only. A person in repose, breathing normally, will be at the top of tidal volume when their lungs are at their highest, or largest, during such a breathing cycle. When the procedure requires the subject to 'exhale' or exhale in the water, the subject relaxes completely while allowing air to gradually flow out of the lungs, not forcing it out, until they reach 'functional residual capacity' (FRC) and no less. A person in repose, breathing normally, will be at FRC when their lungs are at their lowest, or smallest, during such a breathing cycle.

5.6.6.1.2 The test according to 5.6.6.3 b) is to demonstrate that a buoyancy aid according to ISO 12402-5, that is not designed to self right the wearer provides adequate face-up stability, and associated resistance to being turned face down by waves or other forces.

5.6.6.2 Apparatus

For testing PFDs according to ISO 12402-1 to ISO 12402-5 the reference vest used shall be constructed in accordance with Annex B.

5.6.6.3 Procedures

During testing the panel shall observe whether any closure fails to remain secure.

Unless otherwise specified, for each of the following procedures, as the subject places the face in the water the lungs shall be near the top of tidal volume by instructing the subject to take a normal breath or half breath.

For lifejackets according to ISO 12402-1, the tests shall be repeated with each test subject in the reference vest.

The PFD shall be tested on each test subject by carrying out the following tests as called for by its intended performance level, in the relevant part of ISO 12402 applicable to its intended classification.

a) Leg release righting test

Facing away from the test assistant, the subject shall attain a face-down horizontal position in the water, but with mouth held out of the water. The feet shall be supported, shoulder-width apart with the heels at the surface of the water, by a test assistant. The subject shall be instructed in the following sequence:

— straighten the legs;

— put the arms along the sides;

— allow the arms, shoulders, and body to completely relax;

— lower the face into the water while breathing out normally; and

— relax the neck.

During the relaxation phase, the test assistant shall maintain the subject in a stable position. Immediately after the subject has relaxed with the face in the water, the test assistant shall release the subject's feet. The subject shall remain limp while the turning time is measured. The turning time is determined from the release of the feet until the subject's mouth is clear of the water, to the nearest 0,1 s. The test shall be conducted six times, discarding the highest and lowest turning times and averaging the remaining four times.

NOTE Child subjects not able to relax the arms are instructed to straighten the arms along the sides.

b) Vertical stability test

During the test, the panel shall observe whether any closure fails to remain secure.

For determination of the floating position of buoyancy aid, each subject shall don the device and enter the water. The subject shall then assume an upright, slightly behind vertical position in the water, keeping the head, torso, and legs in the same plane, while holding the arms at the sides. A straight rod with an inclinometer attached may be used to establish the starting position is $5° \pm 2°$ degrees behind vertical. The subject shall maintain this position until the device induces motion (forward or backward of vertical). Then, the subject shall allow the arms, legs, torso, and head to assume their naturally relaxed positions so that the head falls in the direction of induced motion. If motion is not induced, the subject shall allow the head to fall backwards and then allow the arms, legs, and torso to assume their naturally relaxed positions. After the subject has attained an attitude of relaxed static balance, the freeboard of the subject shall be measured while the subject is at the lowest level attained during the normal breathing cycle.

5.6.6.4 Results

5.6.6.4.1 Report whether any closure securing the PFD to the body does not remain secure during the tests.

5.6.6.4.2 For lifejackets according to ISO 12402-1 to ISO 12402-4, report the average time to bring each test subject's mouth clear of the water without him/her having to carry out any voluntary movement.

5.6.6.4.3 For buoyancy aids according to ISO 12402-5, report whether

a) each subject is maintained in an attitude of relaxed static balance (such as an upright or backward position) so that the subject's respiration is not impeded at any time;

b) there is any tendency to turn a subject face-down from the position of relaxed static balance in the water;

c) there is any negative freeboard.

If any of these conditions is not fulfilled, the device is considered to have failed.

5.6.7 Ergonomics

5.6.7.1 Principle

While being observed by the test panel, the test subjects shall assess comfort and interference with motion when using the PFD to determine whether the PFD is fit for the intended and emergency use.

5.6.7.2 Procedure

5.6.7.2.1 General

The test panel shall observe ease of movement and elicit comments from the subjects relating to comfort or interference with desirable behaviour or movements during all the human subject tests. The panel shall pay particular attention to

a) head and limb movement, and their potential to interfere with emergency use or the subject desiring to remove the PFD due to discomfort, and

b) any interference with vision, hearing or breathing.

Assessments shall be made both out of and in the water, and with the PFD both inflated and uninflated, if applicable.

The panel shall assess donning/secondary-donning actions, swimming and encumbrance.

5.6.7.2.2 Inflation

An inflatable PFD shall permit the user to top up the inflation by mouth while in or out of the water using either hand independently.

5.6.7.2.3 Oral inflation

Test according to 5.5.10.2.2.

5.6.7.2.4 Encumbrance assessment

The test panel shall observe ease of movement and elicit comments from the subjects during the following activities:

a) sitting in a liferaft simulating awaiting rescue;

b) climbing a distance of 2 500 mm up and down a vertical ladder;

c) drinking from a cup;

d) touching toes;

e) accessing and using any additional items provided on or with the PFD, such as whistle, buddy line, light;

f) tightening and loosening of all essential adjustments.

These assessments shall be made out of the water, and both inflated and uninflated, if applicable. These assessments are not required for PFDs under 100 N buoyancy.

Additionally, the panel shall consider comfort and encumbrance

a) during and after donning,

b) during water entry and swimming tests, and

c) during the boarding test.

5.6.8 In-water stability test

5.6.8.1 Principle

This test is to assess the ability of a PFD to safely support the user.

5.6.8.2 Procedure

The test subject shall attain a relaxed face up position of static balance in the water with shoulders and back toward the test conductor. The subject shall be instructed to place elbows against his/her sides, hands on stomach, under the PFD if possible, and bring the knees up as close to the chest as possible while keeping them together. The test conductor shall grasp the subject's shoulders and rotate the subject clockwise around the longitudinal axis of the torso so that the subject attains a $(55 \pm 5)°$ list. The subject shall then be released. It shall be observed whether the subject returns to a stable face-up position. This test shall be repeated, but the subject is rotated counter-clockwise.

5.6.8.3 Results

Report whether the candidate device did or did not return the subject to a stable face-up position according to 5.6.6.3. If applicable, report whether the reference vest did or did not return the subject to a face-up position. See also 5.3.

5.6.9 Tests using child manikins

5.6.9.1 General

The tests shall be used to assess PFDs designed for children of less than 20 kg using manikins. An example of a relevant manikin is described in Annex E.

The manikin shall be dressed in a close-fitting non-buoyant bathing suit. The manikin harness shall be fitted and the PFD shall then be donned on the manikin, over the harness, following the manufacturer's instructions.

All tests shall be carried out in an indoor pool, in calm water.

NOTE A study on infant and baby manikins for lifejackets in Japan is available at Japan Marine Standards Association, Surnitorno Fudosan Bldg. 4, 7th, 7-12-14, Ueno, Taito-ku, Tokyo, 110-0005 Japan.

5.6.9.2 Test order

The tests shall be carried out in one sequence and in the order given in 5.6.9.2.1 to 5.6.9.2.3.

5.6.9.2.1 Series 1:

a) fall from sitting position on pool-side, 500 mm above water surface (face-forward);

b) mouth freeboard;

c) fall from sitting position on pool-side, 500 mm above water surface (face-forward);

d) mouth freeboard;

e) fall from sitting position on pool-side, 500 mm above water surface (face-forward);

f) mouth freeboard;

g) body angles;

h) self-righting;

i) mouth freeboard (conscious, central head position).

Remove from water and inspect for damage.

5.6.9.2.2 Series 2:

a) fall from 1 000 mm (forward-bent);

b) mouth freeboard;

c) fall from 1 000 mm (forward-bent);

d) mouth freeboard;

e) fall from 1 000 mm (forward-bent);

f) mouth freeboard.

Remove from water and inspect for damage.

5.6.9.2.3 Series 3:

a) fall from 3 000 mm (forward-bent);

b) mouth freeboard;

c) fall from 3 000 mm (forward-bent);

d) mouth freeboard;

e) fall from 3 000 mm (forward-bent);

f) mouth freeboard.

Remove from water and inspect for damage.

5.6.9.3 Fall from a height

5.6.9.3.1 Principle

The principle is to assess the performance of a PFD when the manikin is dropped into the water from a height of (500 ± 50) mm, (1 000 ± 50) mm or (3 000 ± 50) mm.

5.6.9.3.2 Procedure

The PFD shall bring the manikin to the surface within 5 s of impact. The manikin shall then float in a face-up posture with the mouth clear of the water. There shall be no functional damage to the PFD.

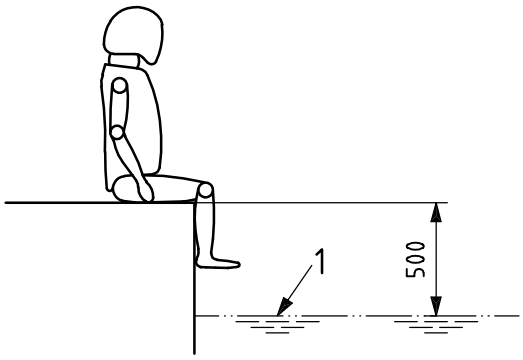
For the drop from the pool-side, the manikin shall be seated at a height of 500 mm above the water surface. Slight even pressure shall be placed on the back of the shoulders, pushing the manikin forwards into the water. See Figure 13.

For the drops from 1 000 mm and 3 000 mm, the quick-release system and line shall be attached to the harness using the D-ring at the back of the neck. Ensure that the PFD is not hindered in any way by the release system. The manikin shall be suspended in a forward-bent position, with the bottom of the feet 1 000 mm or 3 000 mm above the water surface for the drops from 1 000 mm and 3 000 mm, respectively. See Figure 14.

The manikin shall be released, and submersion time recorded as the time from the manikin hitting the water to the time when the mouth markers are seen above the water surface.

Three tests shall be performed at each height. The PFD shall be inspected for displacement after each test and then adjusted. After the third drop, the PFD shall be inspected for damage.

Dimensions in millimetres

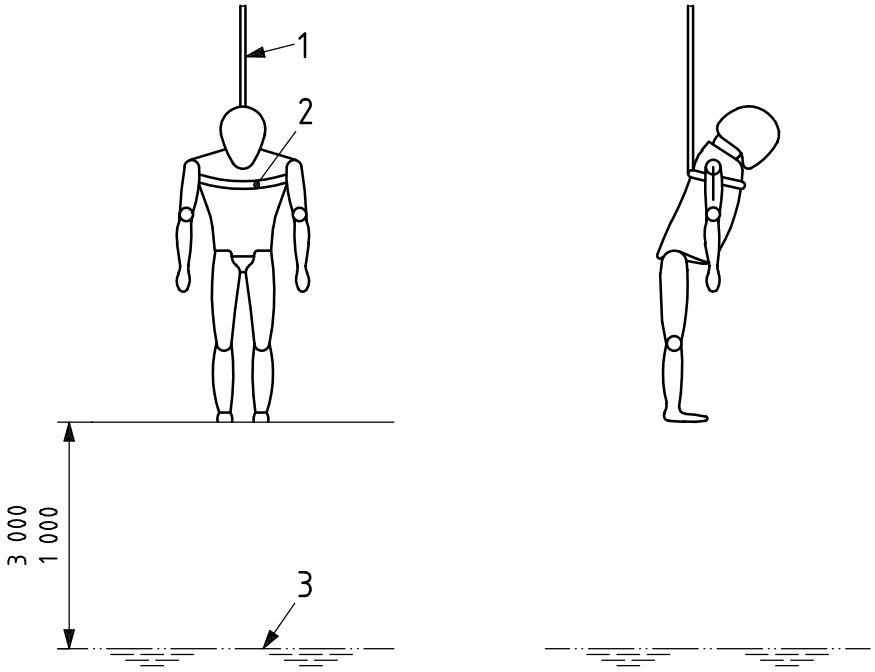


Key

1 water surface

Figure 13 — 500 mm fall from pool-side

Dimensions in millimetres



Key

1 line
2 harness with quick-release system at back of neck
3 water surface

Figure 14 — Forward-bent drop

5.6.9.4 Mouth freeboard

5.6.9.4.1 Principle

The principle is to ensure that the lower corner of the mouth is held at a sufficient height above the water surface.

The risk of water washing over the face of the child is to be reduced.

5.6.9.4.2 Procedure

For a device for measuring freeboard, see 5.6.2. The plastic disc at the free end of the measuring tape shall be reduced to a diameter of (20 ± 5) mm.

The tape shall be lowered to the marker at the lower corner of the mouth.

Following a drop test, mouth freeboard shall be measured without adjustment to the position of the head (the unconscious position). Three measurements of mouth freeboard shall be made at each drop height. To pass the test, two out of the three measurements shall meet the requirement.

Following the self-righting test, a single measurement of mouth freeboard shall be made with the head adjusted to a central (conscious) position in line with the body without adjusting the position of the PFD on the manikin.

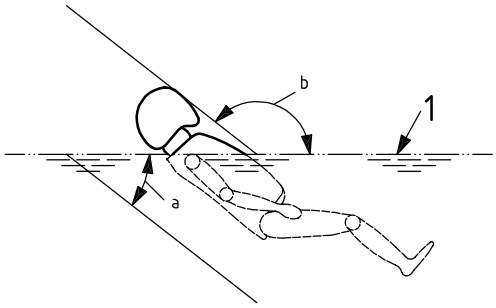
To assess the angle of the body in relation to the water surface following a fall into water, the body shall float in a face-up position. See Figure 15. The head shall be bent slightly forward relative to the torso, with the nose above the mouth.

NOTE If the head of an unconscious child was horizontal, the child could choke due to the tongue blocking the respiratory tract.

Measure the angle of the face in relation to the horizontal, using an imaginary line from the chin to the forehead.

Measure the angle of the body trunk in relation to the horizontal, using an imaginary line from the shoulder to the hip.

The angle of the trunk shall be measured underwater, to reduce any effect due to the refraction properties of water. The angle shall be measured from the side and not over the chest.



Key

1 water surface

a Trunk angle.

b Face-plane angle.

Figure 15 — Body angles

5.6.9.5 Stability and self-righting

5.6.9.5.1 Principle

The principle is to measure the time taken for a PFD to turn the manikin from a face-down to a face-up position with the mouth clear of the water surface. Many children, particularly those who cannot swim, will panic if they fall into the water. Therefore the PFD shall turn a child onto its back with ease, and only be stable in that position.

5.6.9.5.2 Procedure

With the manikin starting in a face-up floating position, one shoulder of the manikin shall be pushed under-water, through an angle of 90°. It shall be assessed whether the manikin returns to the face-up position. Repeat, pushing down the opposite shoulder.

To assess self-righting, turn the manikin onto its front in the face-down floating position, with arms and legs in-line with the body. Hold the manikin by the shoulders, in this horizontal position, without applying any significant downward force. Once in the correct position, release.

Time self-righting from the point when the manikin is released to the point when the marked mouth of the manikin is clear of the water surface.

The self-righting test shall be repeated a further two times. All three tests shall meet the requirement for the PFD to pass.

Annex A
(informative)

Classification of personal flotation devices

A.1 Classification

A.1.1 Classes

A.1.1.1 Lifejackets

These devices provide face-up flotation with levels of support sufficient for various open and rough water uses. Lifejackets have a buoyancy distribution sufficient to turn most users, when tested on users wearing swimming costumes according to ISO 12402, to a position where the mouth has a defined freeboard above the water's surface, even when the user is unconscious.

A.1.1.2 Buoyancy aids

These devices should be comfortable for continuous wear and provide lift, without significant face-up turning ability, to float the conscious user with the level of support marked on the device. Buoyancy aids shall at least be suitable for sheltered waters, but at higher performance levels may be suitable for some users in other waters.

A.1.1.3 Special purpose lifejackets and buoyancy aids

These devices perform as in A.1.1.1 and A.1.1.2 with different levels of support, but have modifications related to special applications for use. These applications shall not relate to essential requirements such as in-water performance, stability and safety in use. The specific conditions for use shall be stated on their label to maintain essential requirements.

A.1.2 Performance levels

A.1.2.1 Level 275

This level is intended primarily for offshore use under extreme conditions. It is also of value to those who are wearing clothing which traps air and which may adversely affect the self-righting capacity of the lifejacket. It is designed to ensure that the user is floating in the correct position with his mouth and nose clear of the surface.

See ISO 12402-2.

A.1.2.2 Level 150

This level is intended for general application or for use with foul weather clothing. It will turn an unconscious person into a safe position and requires no subsequent action by the user to maintain this position.

See ISO 12402-3.

A.1.2.3 Level 100

This level is intended for those who may have to wait for rescue, but are likely to do so in sheltered water. The device should not be used in rough conditions.

See ISO 12402-4.

A.1.2.4 Level 50

This level is intended for use by those who are competent swimmers and who are near to bank or shore, or who have help and a means of rescue close at hand. These garments have minimal bulk, but they are of limited use in disturbed water, and cannot be expected to keep the user safe for a long period of time. They do not have sufficient buoyancy to protect people who are unable to help themselves. They require active participation by the user.

See ISO 12402-5.

Annex B
(normative)

Adult reference vest for test-subject disqualification and test-subject group validation

B.1 General

This annex specifies the design and construction of the adult lifejacket used to disqualify individual test subjects and to verify that the group of test subjects used represents a valid cross-section of the adult population when testing lifejackets according to ISO 12402-1 to ISO 12402-6.

B.2 Description

The reference vest is made with two types of buoyant foam in a vest style using a heavy nylon cover fabric shell secured to the body with 25 mm webbing, closures, and adjustments. The shell is made with slide fasteners (zippers) in place of closing seams to hold the foam within, in order that the foam inserts can be easily removed to check their buoyancy and renew or supplement them if they are out of tolerance. Hook and loop fasteners are used on the interior foam retainers to position and prevent shifting of the foam panels. The vest is designed to fit persons of a chest size from 700 mm to 1 350 mm and to be comfortable to use as a non-reversible device such that it would be obvious to the user as to which is the inside and outside of the device, even under reduced lighting conditions.

B.3 Materials

B.3.1 General

All materials used shall comply with ISO 12402-7.

B.3.2 Foam requirements

B.3.2.1 General

The performance of the reference vest is dependent on having the proper foam stiffness and shapes.

B.3.2.2 Stiffness

Two foams of different stiffness are used: one is a soft foam and the other is a stiff foam. A bridge deflection test is provided to determine acceptability for the intended application. Figure B.1 provides the set-up details and Table B.1 provides the specific measured values. For selecting the type of foam for the specific insert, see Tables B.2 and B.3. To measure the center deflection of a foam panel of the specified cross-section ($a \times b$) and 110 mm wide, place the foam panel centered across the two equal height, parallel, horizontal surfaces separated by the specified distance (c), and then load with a mass of the specified width. Note the length of the load shall be at least 110 mm, such that when placed on the foam panel it will extend the full width of the foam panel. The load may extend beyond the width of the foam panel provided that it is centered over the panel with equal amounts extending over the sides of the foam panel. Measure the deflection at the bottom center location of the foam panel 30 s after placing the load on the panel.

B.3.2.3 Shape

The shape of each foam insert is specified in Figures B.8 to B.11. For dimensions, see Tables B.2 and B.4.

B.3.2.4 Buoyancy

The total design buoyancy of the inserts is 149 N. Table B.3 specifies, for each insert, the buoyancy and buoyancy tolerances. These values apply to both new and used inserts. Table B.3 also specifies the buoyancy distribution between the front and back inserts and the tolerance.

B.3.3 Other component requirements

See Table B.2.

B.4 Construction

B.4.1 The construction and assembly of the device shall be in accordance with Tables B.2 to B.4 and Figures B.2 to B.14.

B.4.2 The seam allowances are 13 mm, unless otherwise specified.

B.4.3 All structural seams use a lock-type stitch so that the seam will not unravel when a force is applied in the direction of the seam on any of the threads forming the stitch. Stitching should have a density of 7 stitches to 12 stitches per 25 mm of stitch length. The box-x stitching on the webbing is 15 mm × 18 mm, unless otherwise specified. The bar-tack stitching on the webbing is 15 mm × 2 mm.

B.4.4 On the closing seam of the back section of the outer and inside covers, the cut ends of the fabric are turned under and stitched so that the fabric will not ravel. The cut ends of webbing should be heat-sealed.

B.4.5 A tab on the ends of the waist belt is formed by turning under 40 mm of material twice and stitching 19 mm from the end of the folds with box-x or bar-tack stitching.

B.4.6 A tolerance of ± 6 mm is used throughout for fabric cutting and stitching assembly. A tolerance of ± 6 mm is also used for foam cutting; however, the buoyancy requirements of Table B.3 shall be met.

a) Initial set-up **b) Bridge deflection after 30 s**

Key

1 load, centered over gap *c*

2 foam

Figure B.1 — Foam bridge deflection test

Table B.1 — Specifications for the foam bridge deflection test

Foam type	Dimension shown in Figure B.1 mm						Load mass kg
	a (length)	(Not shown) (width)	*b* (thickness)	*c* (span)	*d* (load width)	*e* (deflection)	
Stiff	394	110	83	300	120	< 20	8,6
Soft	394	110	45	150	30	$\geqslant 25$	0,75

Table B.2 — Parts, quantity and assembly

Component	Description	Quantity	See Figure	Construction notes
1 Cover fabric	420 denier nylon, with ravel-resistant coating, orange			
1.1 Front outer cover		1	B.2	
1.2 Back outer cover		1	B.2	
1.3 Inside cover		1	B.3	
1.4 Center gusset		2	B.4	
1.5 Collar, outer and inside cover		2	B.5	
1.6 Fabric reinforcement		4	B.6 B.14	Attach to inside of collar cover, as attachment 1, for reinforcement at webbing attachment (see Figure B.14).
1.7 Interior fabric retainers for foam inserts 1		2	B.7 B.13	Attach to inside of front cover, as attachment 3, stitch to cover at each side to form a foam retainer for inside front foam insert components 2.2.1 and 2.2.2 (see Figure B.13).
1.8 Interior fabric retainers for foam inserts 2		2	B.7 B.14	Attach hoop and loop fasteners to the ends and stitch at center to the inside of front cover, as attachment 4, to form a foam retainer for front foam insert components 2.1.1 and 2.1.2 (see Figure B.13).
2 Foam				
2.1 Stiff	See Tables B.1 and B.3			
2.1.1 Front foam insert, right side	81 mm thick	1	B.8	
2.1.2 Front foam insert, left side	81 mm thick	1	B.8	
2.1.3 Collar foam insert	56 mm thick	1	B.10	
2.2 Soft	See Tables B.1 and B.3			
2.2.1 Inside front foam insert, right side	46 mm thick	1	B.9	
2.2.2 Inside front foam insert, left side	46 mm thick	1	B.9	
2.2.3 Back foam insert	32 mm thick	1	B.11	

Table B.2 (*continued*)

Component	Description	Quantity	See Figure	Construction notes
3 Webbing	25 mm, polypropylene, with easy adjustment and no significant slippage when used with the specified hardware.			
3.1 Chest strap	127 mm, black	2	B.12	On left side of front cover, attach webbing with male buckle. On right side of front cover, attach webbing with female buckle. The free ends of the chest strap are folded under the yellow webbing (collar attachment webbing), with reinforcing fabric (see Figure B.6) on inside of cover fabric. A box-x stitch is used to attach the chest strap to the front cover.
3.2 Waist belt	152 mm, black	2	B.12	On left side, attach waist belt with slide and buckle clip waist belt. On right side, attach bottom belt with D-ring and slide.
3.3 Waist belt	1 867 mm, black	1	B.12 B.13	Form 40 mm tab on each end. Attach to back cover using three box-x stitches (after front and back covers are assembled).
3.4 Belt loop on front cover	76 mm, black	2	B.12	Attach webbing to front outer cover and form a belt loop (one on each side) by two sets of double bar tack stitches.
3.5 Belt loop on inside cover	89 mm, black	2	B.13	Attach webbing to inside cover and form a belt loop (one on each side) by two box-x stitches.
3.6 Collar attachment	1 384 mm, yellow	1	B.14 B.6 B.12	Attach webbing to collar and reinforcing fabric, in two places using box-x stitch.
4 Hook and loop fastener	50 mm × 70 mm, black generic	2	B.13 B.7	Hook and loop fasteners are attached to the ends of interior fabric retainer for foam insert.
5 Thread	Generic synthetic	AR		
6 Hardware				
6.1 Buckle	Male and female 25 mm, plastic, 890 N single-end strength	1		Chest strap
6.2 Slide	Adjuster 25 mm, plastic, 1 600 N single-end strength	2		Waist belt
6.3 Snap hook	25 mm, stainless steel, 1 600 N single-end strength	1		Waist belt
6.4 D-ring	25 mm, stainless steel, 1 600 N single-end strength	2		Waist belt
6.5 Zipper	280 mm, plastic (zipper chain and pulls)	1	B.14	Foam access for collar cover
6.6 Zipper	370 mm, plastic (zipper chain and pulls)	1	B.12	Foam access for back cover
6.7 Zipper	440 mm, plastic (zipper chain and pulls)	2	B.12 B.13	Foam access for front cover

Table B.3 — Foam insert specifications

Values in newtons

Insert	Front right	Front left	Inside front right	Inside front left	Back	Collar
Foam type [a]	Stiff	Stiff	Soft	Soft	Soft	Stiff
Buoyancy [b]	34 ± 1,2	34 ± 1,2	17,5 ± 0,65	17,5 ± 0,65	18 ± 0,8	28 ± 1

[a] The buoyancy of most foams will change over time with the greatest change occurring in the first several months after manufacture. The exact kind of foam selected will need to be evaluated to determine the amount of additional buoyancy needed at the time of manufacture to maintain the values specified.

[b] Buoyancy distribution: 69 % front ± 1,5 %.

Table B.4 — List of dimensions shown in Figures B.2 to B.14

Dimensions in millimetres

Dimension	Figure											
	B.2	B.3	B.4	B.5	B.6, B.7	B.8	B.9	B.10	B.11	B.12	B.13	B.14
a	72	294	23	308	73	198	76	20	188	100	100	25
b	298	100	516	142	73	46	46	56	274	35	35	160
c	438	1 106	618	10	130	76	394	51	414	20	20	53
d	442	199	102	288	205	81	38	216	343	35	300	25
e	432	398		342	72	76	51	229	147	120	30	45
f	141	597		476	470	157	165	259	223	260		
g	100	1 124		65		394		45		85		
R								70				
h	705	141				46				40		
i	199					8				55		
j	398					20				225		
k	188					20				75		
l	723					76						
m						46						
n						38						
o						165						
p						25						

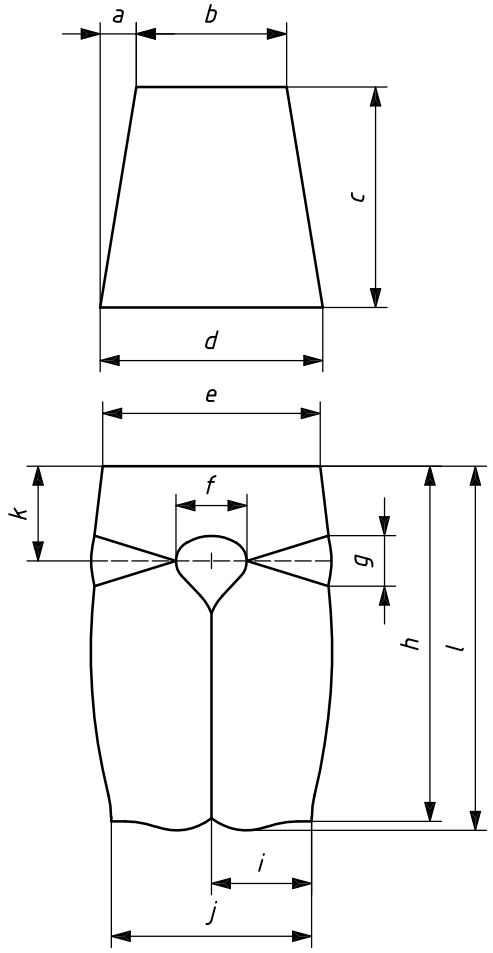


Figure B.2 — Outer cover, front and back sections

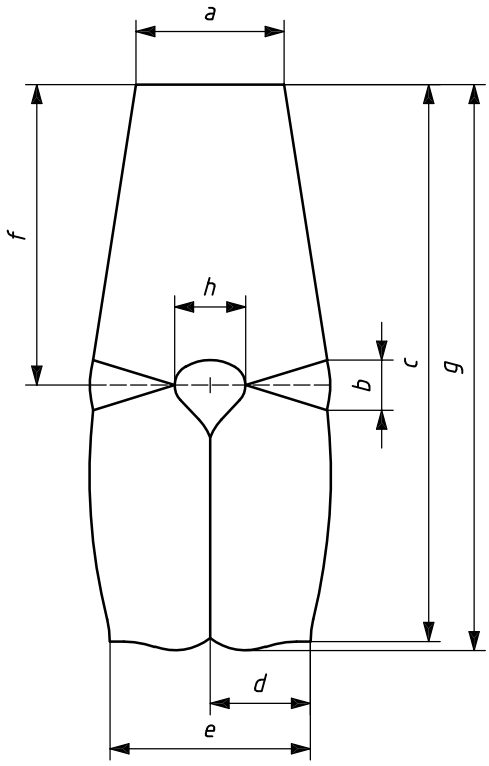


Figure B.3 — Inside cover

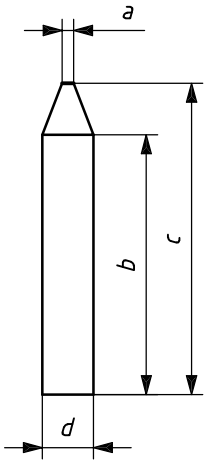


Figure B.4 — Center gusset

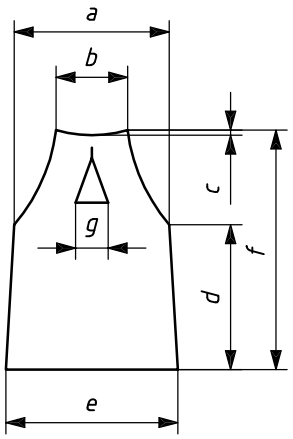


Figure B.5 — Outer and inside cover, collar

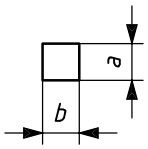
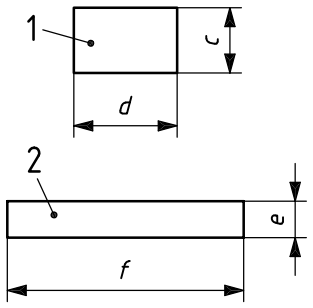


Figure B.6 — Fabric reinforcement

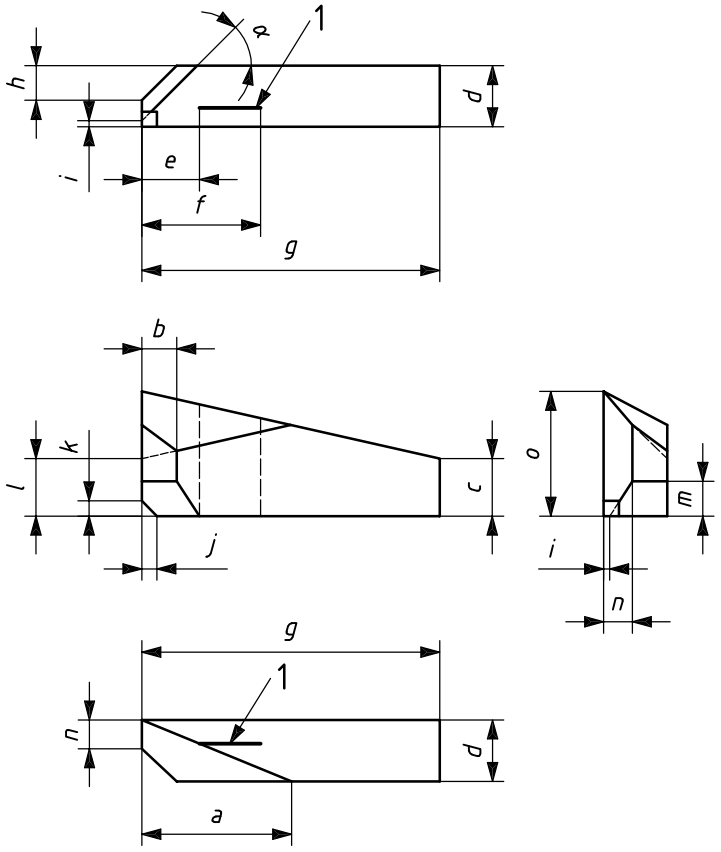


Key

1 interior fabric retainers for foam inserts 1

2 interior fabric retainers for foam inserts 2

Figure B.7 — Interior foam retainer



Key

1 slot

α 45°

Figure B.8 — Front foam insert

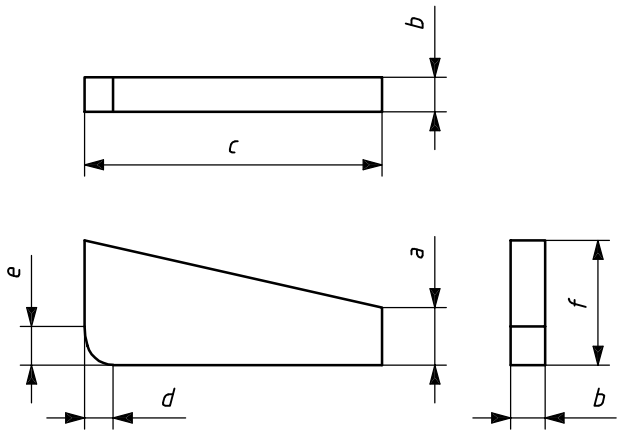
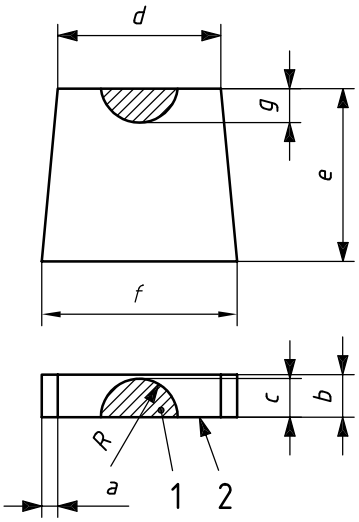


Figure B.9 — Inside front foam insert



Key

1 skive
2 side towards body

Figure B.10 — Collar foam insert

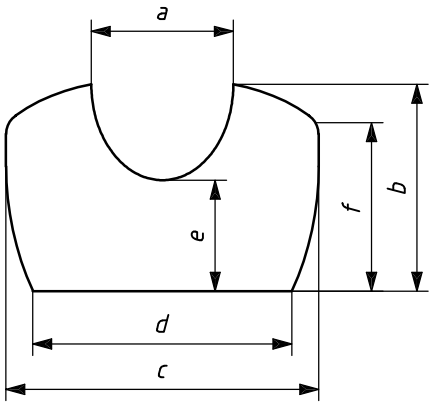
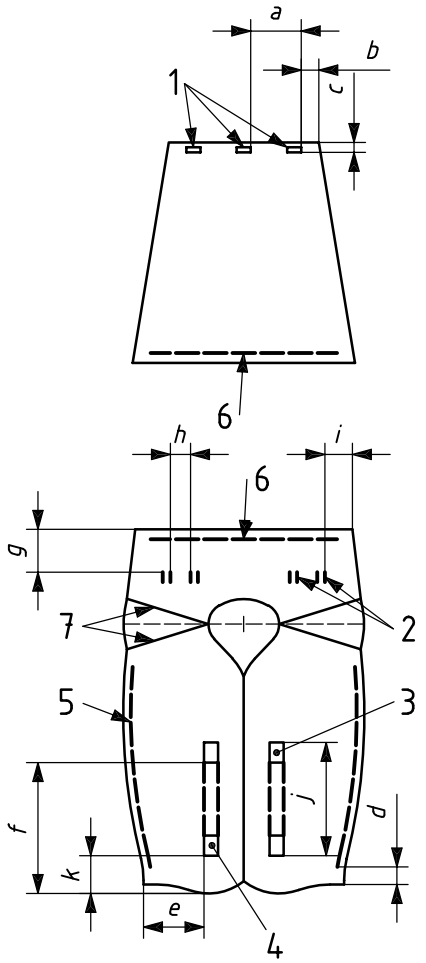


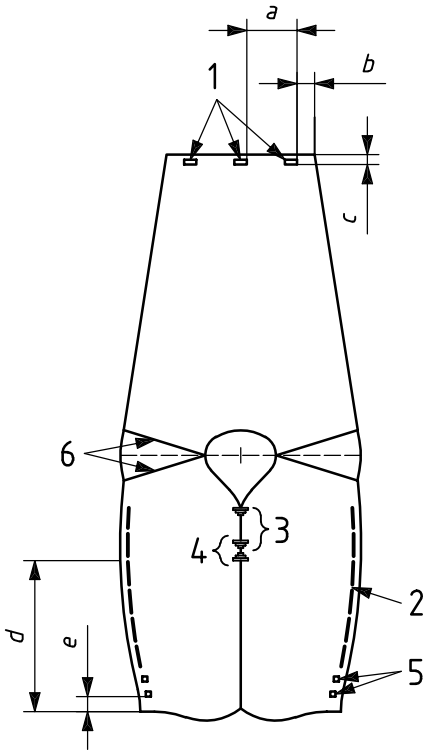
Figure B.11 — Back foam insert (thickness = 25 mm)



Key

1 waist belt (1 867 mm) attachment to outside of back cover
2 zipper (440 mm) attachment to front
3 chest strap (webbing (127 mm) attachment to outside of front cover
4 waist belt (152 mm) attachment to outside of front cover
5 belt loop webbing (76 mm) attachment to outside of front cover
6 zipper (370 mm) attachment to the front and back covers
7 dart

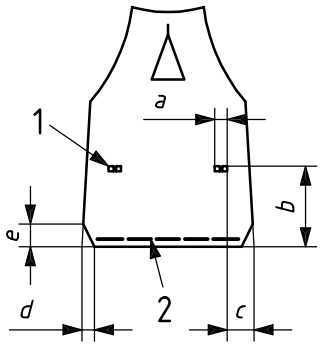
Figure B.12 — Attachments to front and back cover



Key

1 waist belt (1 867 mm) attachment to outside of back cover and inside cover (see Figure B.12)
2 zipper (440 mm) attachment
3 interior fabric retainer attachment to inside front cover
4 interior fabric retainer attachment to center of inside front cover
5 belt loop webbing (89 mm) attachment to outside of cover
6 dart

Figure B.13 — Attachments to inside cover



Key

1 collar webbing (1 384 mm) attachment on the outside of the inner cover with reinforcement fabric inside
2 zipper (280 mm) attachment to the outer and inner covers

Figure B.14 — Attachments to outer and inside collar cover

Annex C
(normative)

Child reference vest for test subject disqualification and test subject group validation

C.1 General

This annex specifies the design and construction of the child lifejacket used to disqualify individual test subjects and to verify that the group of test subjects used represents a valid cross-section of the potential user population when testing lifejackets according to ISO 12402-1 to ISO 12402-6.

C.2 Description

This reference vest is made with layers of buoyant foam in a bib-style design using a heavy nylon shell cover fabric secured to the body with a waist belt with quick and positive closure and adjustment, along with a chest strap at the neck for closure and adjustment. The shell is made with slide fasteners (zippers) in place of closing seams to hold the foam within, in order that the foam inserts can be easily removed to check their buoyancy and renew or supplement them if they are out of tolerance. The vest is designed to fit persons of chest size from 500 mm to 700 mm. The vest was designed to be reasonably comfortable to use as a non-reversible device.

C.3 Materials

C.3.1 General

All materials used shall comply with ISO 12402-7.

C.3.2 Foam requirements

C.3.2.1 Stiffness and quality

The buoyant inserts are made of layers of medium stiffness foam to create a flexible but firm buoyancy element.

C.3.2.2 Shape

The shape of each foam layer is identified in Figures C.2 and C.3. Dimensions are given in Tables C.1, C.2 and C.3.

C.3.2.3 Buoyancy

The total design buoyancy of the device is 88 N. Table C.4 identifies, for each insert, the buoyancy, buoyancy tolerances, and distribution when checked at the time of testing.

C.3.3 Other component requirements

See Table C.1.

C.4 Construction

C.4.1 The construction and assembly of the device shall be in accordance with Tables C.1 and C.5 and Figures C.1 through C.9.

C.4.2 Seam allowances are 13 mm, unless otherwise specified.

C.4.3 All structural seams use a lock-type stitch so that the seam will not unravel when a force is applied in the direction of the seam on any of the threads forming the stitch. Stitching should have a density of 7 stitches to 12 stitches per 25 mm of stitch length. Box-x stitching on the webbing is 30 mm × 15 mm for the waist belt and 15 mm × 13 mm for the belt loop and chest strap, unless otherwise specified. The bar-tack stitching on webbing is 30 mm × 2 mm for the waist belt and 15 mm × 2 mm for the belt loop and chest strap.

C.4.4 The fabric reinforcements for the waist belt, belt loop, and chest strap should be attached to the inside surface of the outside cover before attaching any of these items. On the closing seam of the top and bottom sections of the outside and inside cover, the cut ends of the fabric are turned under and stitched when installing the zippers so that the fabric will not ravel and so that the folds are flush with the line where the zipper teeth mesh (zippers installed to be hidden by cover fabric when closed).

C.4.5 A tolerance of ± 6 mm is used throughout for fabric cutting and stitching assembly. A tolerance of ± 6 mm is also used for foam cutting; however, the buoyancy requirements of Table C.4 shall be met.

Table C.1 — Parts, quality and assembly

Component	Description	Quality	See Figure	Construction notes
1 Cover fabric	420 denier nylon, with ravel-resistant coating, orange			
1.1 Outside cover		1	C.1, C.4, C.9	
1.2 Inside cover		1	C.1, C.4, C.9	
1.3 Fabric reinforcement, chest strap		2	C.5, C.9	Attach one each to inside left and right outside covers for the chest strap. Use lock stitches on three sides each (see Figure C.9 for locations).
1.4 Fabric reinforcement, belt, and belt loop		2	C.5, C.9	Attach to inside left and right outside covers for the waist belt and belt loop. Use lock stitches on three sides (see Figure C.9 for location).
2 Foam	7 mm thickness, polyethylene foam, except for one layer as needed to achieve required buoyancy			Layers stacked per Figures C.2 and C.3.
2.1 Front foam insert, left		13 layers	C.2	Trim corners per Figure C.2, except layers C through E.
2.2 Front foam insert, right		13 layers	C.2	Trim corners per Figures C.2, except layers C through E.
2.3 Back foam insert		11 layers	C.3	

Table C.1 (*continued*)

Component	Description	Quality	See Figure	Construction notes
3 Webbing				All cut ends heat-sealed.
3.1 Waist belt webbing	38 mm, black, polypropylene, with easy adjustment and no significant slippage when used with the specified hardware.	1 285 mm cut length	C.1, C.8, C.9	On left side attach waist belt with fixed part of buckle. Tab on the end of belt formed by turning under 40 mm of material twice and stitching 19 mm from the end of the fold with a bar-tack stitch. For location see Figure C.9.
3.2 Belt loop webbing	19 mm, black, polypropylene.	80 mm cut length	C.1, C.9	Attach webbing to front outside cover with two sets of double bar- tack stitches to form a belt loop. For location see Figure C.9.
3.3 Chest strap webbing	19 mm, black, polypropylene.	235 mm and 80 mm cut length	C.1, C.7, C.9	Attach webbing with female buckle to right outside cover. Attach webbing with male buckle to left outside cover. For location see Figure C.9. Tab formed 75 mm from the free end of the male section of chest strap by folding in "Z" pattern 30 mm apart and stitching 15 mm from the fold with a bar-tack stitch. See Figure C.7.
4 Thread	Generic synthetic	AR		
5 Hardware				
5.1 Buckle	38 mm, plastic (male and female sections)	1	C.1, C.8	Used in waist belt assembly.
5.2 Buckle	19 mm, plastic (male and female sections)	1	C.1, C.7	Used in chest strap assembly.
5.3 Zipper	380 mm, plastic (zipper chain length)	1	C.1, C.9	
5.4 Zipper	150 mm, plastic separating (zipper chain and box/pin length)	2	C.1, C.9	

Table C.2 — List of dimensions shown in Figure C.2

Dimensions in millimetres

Dimension	Insert layer				
	A	B	C	D	E
a	145	140	125	115	95
b	305	300	285	275	255
c	30	30	0	0	0

Table C.3 — List of dimensions shown in Figure C.3

Dimensions in millimetres

Dimension	Insert layer				
	A	B	C	D	E
a	343	335	325	315	305
b	140	133	120	108	95
c	9	5	3	0	– 5
R	46	50	52	55	55

Table C.4 — Foam insert specifications

Property	Left front insert	Right front insert	Back insert
Density	(29 ± 5) kg/m^3	(29 ± 5) kg/m^3	(29 ± 5) kg/m^3
Compressive strength at 25 % (ISO 3386-1)	(35 ± 10) kPa	(35 ± 10) kPa	(35 ± 10) kPa
Buoyancy [a, b]	(31,5 ± 1,2) N	(31,5 ± 1,2) N	(25 ± 1,2) N

[a] The buoyancy of most foams will change over time with the greatest change occurring in the first several months after manufacture. The exact kind of foam selected will need to be evaluated to determine the amount of additional buoyancy needed at the time of manufacture to achieve the values specified.

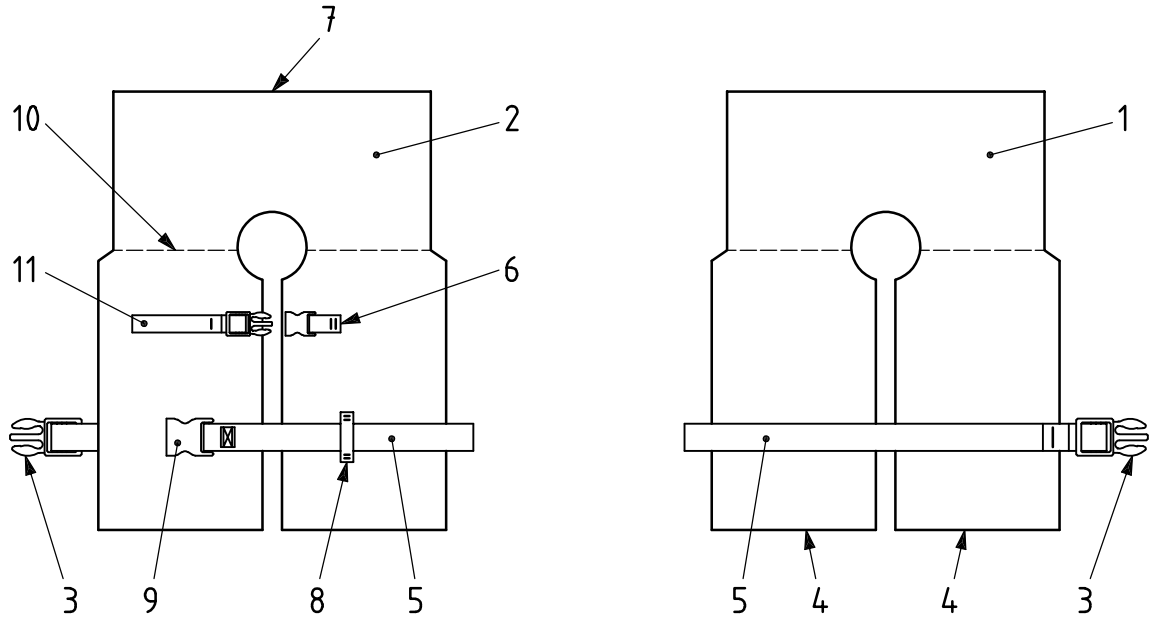
[b] Buoyancy distribution: 71,5 % front ± 1,5 %.

Table C.5 — List of dimensions shown in Figures C.4 to C.9

Dimensions in millimetres

Dimension	Figure C.4	Figure C.5		Figure C.6	Figure C.7	Figure C.8	Figure 9
		Fabric according to No. 1 in the key	Fabric according to No. 2 in the key				
a	420	75	80	75	90	1 150 [a]	45
b	210	105	110		40		135
c	92						85
d	210						45
e	356						25
f	230						33
g	460						115
h	375						25
i	580						265

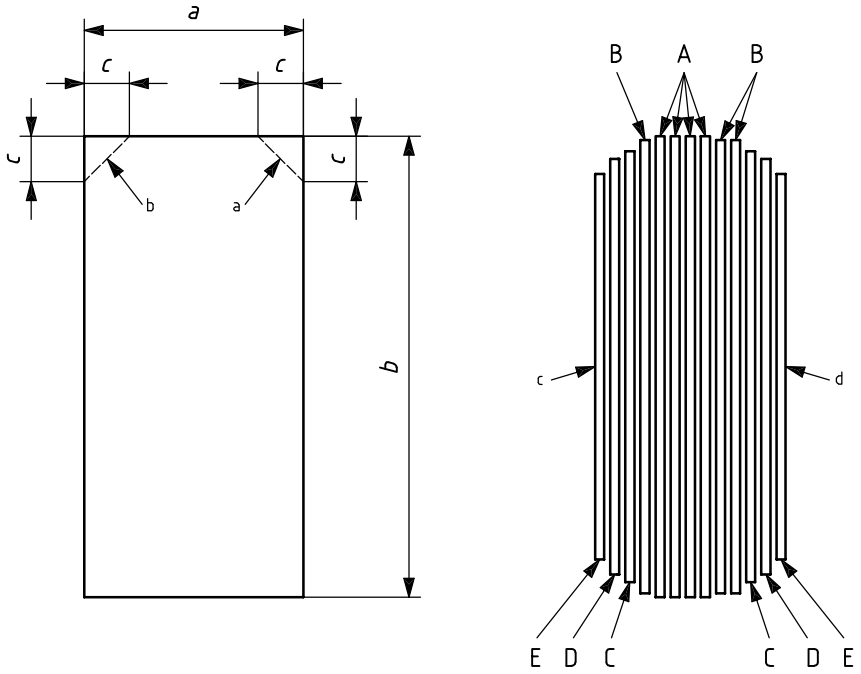
[a] With webbing assembly fully extended.



Key

1 inside cover fabric
2 outside cover fabric
3 adjustable part of closure
4 zippers for access to front right and left foam compartment
5 waist belt
6 fixed part of chest strap
7 zipper for access to back foam compartment
8 belt loop
9 fixed part of closure
10 lock stitch to provide foam compartment separation
11 adjustable part of chest strap

Figure C.1 — General arrangement of the device, right side out (outside and inside)



Key

a Trim upper right corner only for left insert layers according to Table C.2.

b Trim upper left corner only for right insert layers according to Table C.2.

c Outside.

d Inside.

Figure C.2 — Front foam inserts (right and left sides)

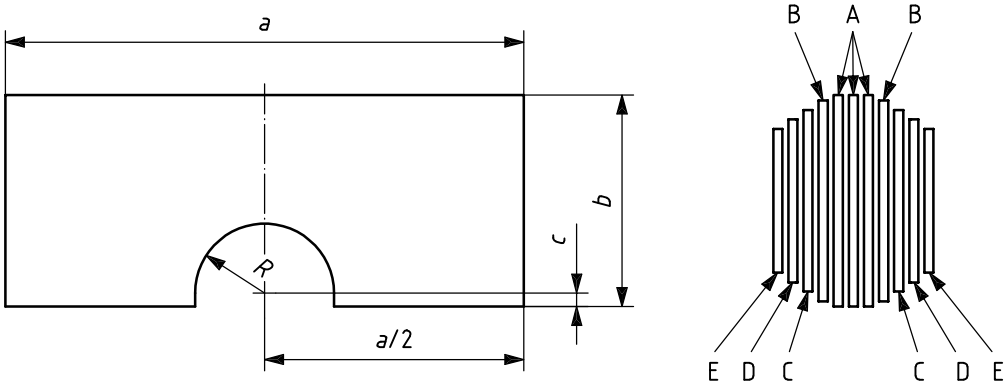


Figure C.3 — Back foam insert

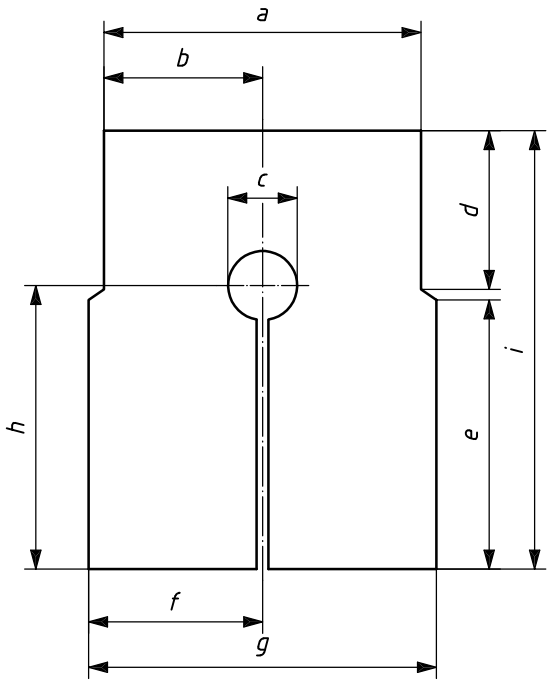
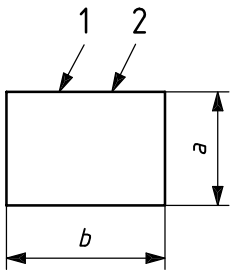


Figure C.4 — Cover cut pattern (outside and inside covers)

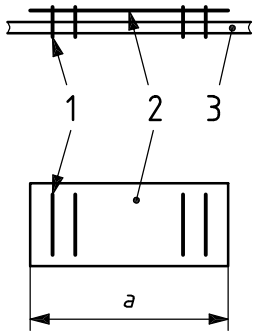


Key

1 fabric reinforcements for chest strap attachments

2 fabric reinforcement for waist belt and belt loop attachments

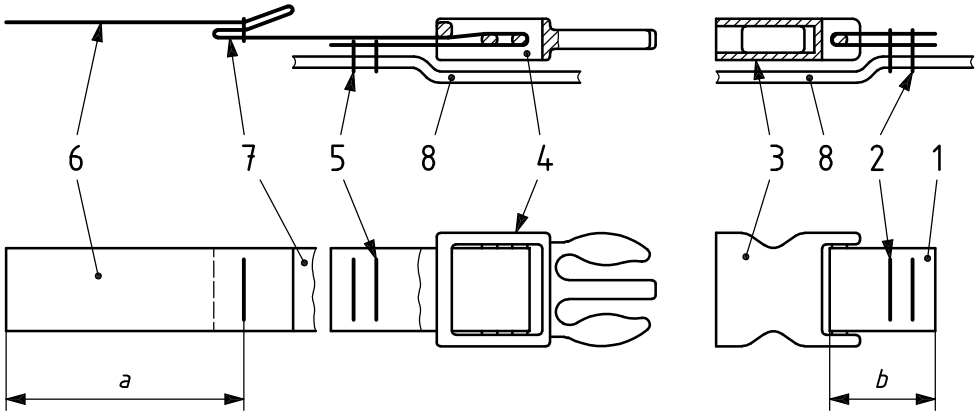
Figure C.5 — Fabric reinforcements



Key

1 bar-tack stitch
2 webbing
3 outer cover and reinforcement (shown on lower view only)

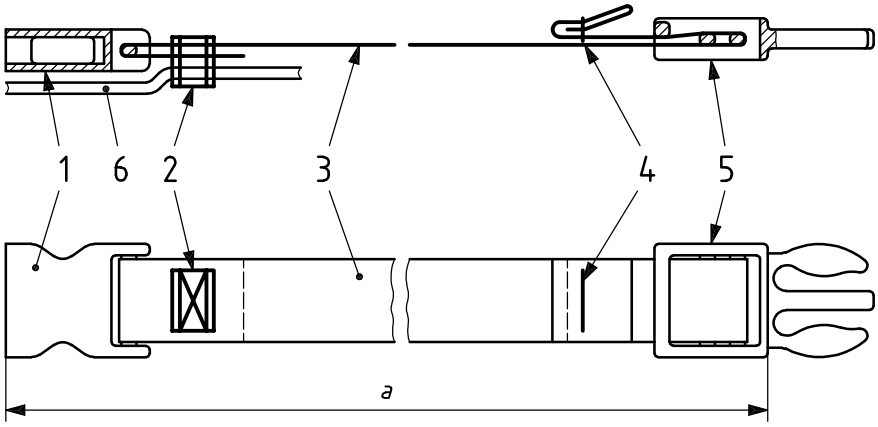
Figure C.6 — Belt loop



Key

1 webbing
2 double bar-tack (or box-x) stitch
3 fixed part of closure
4 adjustable part of closure
5 double bar-tack (or box-x) stitch
6 webbing
7 tab
8 outer cover and reinforcement (shown on lower view only)

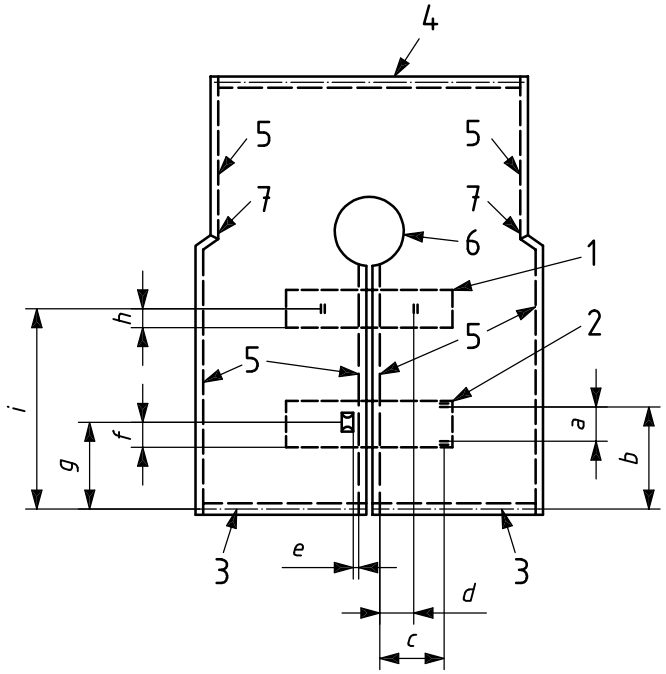
Figure C.7 — Chest strap assembly (adjustable part left and fixed part right)



Key

1 fixed part of plastic closure
2 box-x (or double bar-tack) stitch
3 webbing
4 tab, webbing double-folded and secured with a bar-tack stitch
5 adjustable part of plastic closure
6 outer left cover and reinforcement (shown on lower view only)

Figure C.8 — Waist belt assembly



Key

1 stitching on interior fabric reinforcement for chest strap on right and left sides of the outside cover
2 stitching on interior fabric reinforcement for waist belt and belt loop on right and left sides of the outside cover
3 fabric fold and zipper teeth line of engagement when attached to outside and inside covers
4 fabric fold and zipper teeth line of engagement when attached to outside and inside covers
5 lock-stitch seam (with fabric face to face)
6 lock-stitch with 5 mm seam allowance and over-edge stitch (with fabric face to face)
7 after-stitching cut relief

Figure C.9 — Initial assembly (outside and inside covers)

Annex D
(normative)

Infant reference vest for test subject disqualification and test subject group validation

D.1 General

This annex specifies the design and construction of the infant lifejacket used to disqualify individual test subjects and to verify that the group of test subjects used represents a valid cross-section of the potential user population when testing PFDs according to ISO 12402-1.

D.2 Description

This reference vest is made with layers of buoyant foam in a bib-style design using a heavy nylon shell cover fabric secured to the body with a waist belt with quick and positive closure and adjustment, along with a chest strap at the neck for closure and adjustment. The shell is made with slide fasteners (zippers) in place of closing seams to hold the foam within, in order that the foam inserts can be easily removed to check their buoyancy and renew or supplement them if they are out of tolerance. The vest is designed to fit persons with a chest size of less than 500 mm. The vest was designed to be reasonably comfortable to wear as a non-reversible device.

D.3 Materials

D.3.1 General

All materials used shall comply with ISO 12402-7.

D.3.2 Foam requirements

D.3.2.1 Stiffness and quality

The buoyant inserts are made of layers of medium stiffness foam to create a flexible but firm buoyancy element.

D.3.2.2 Shape

The shape of each foam layer is identified in Figures D.2 and D.3. Dimensions are given in Tables D.1, D.2 and D.3.

D.3.2.3 Buoyancy

The total design buoyancy of the device is 71 N. Table D.4 identifies foam characteristics, the buoyancy for each insert and its tolerances, and the overall buoyancy distribution to be verified when using the PFD for certification testing.

D.3.3 Other component requirements

See Table D.1.

D.4 Construction

D.4.1 The construction and assembly of the device shall be in accordance with Tables D.1 and D.5 and Figures D.1 through D.9.

D.4.2 Seam allowances are 13 mm, unless otherwise specified.

D.4.3 All structural seams use a lock-type stitch so that the seam will not unravel when a force is applied in the direction of the seam on any of the threads forming the stitch. Stitching should have a density of 7 stitches to 12 stitches per 25 mm of stitch length. Box-x stitching on the webbing is 30 mm × 15 mm for the waist belt and 15 mm × 13 mm for the belt loop and chest strap, unless otherwise specified. The bar-tack stitching on webbing is 30 mm × 2 mm for the waist belt and 15 mm × 2 mm for the belt loop and chest strap.

D.4.4 The fabric reinforcements for the waist belt, belt loop, and chest strap should be attached to the inside surface of the outside cover before attaching any of these items. On the closing seam of the top and bottom sections of the outside and inside cover, the cut ends of the fabric are turned under and stitched when installing the zippers so that the fabric will not ravel and so that the folds are flush with the line where the zipper teeth mesh (zippers installed to be hidden by cover fabric when closed).

D.4.5 A tolerance of ± 6 mm is used throughout for fabric cutting and stitching assembly. A tolerance of ± 6 mm is also used for foam cutting; however, the buoyancy requirements of Table D.4 shall be met.

Table D.1 — Parts, quality and assembly

Component	Description	Quality	See Figure	Construction notes
1 Cover fabric	420 denier nylon, with ravel-resistant coating, orange			
1.1 Outside cover		1	D.1, D.4, D.9	
1.2 Inside cover		1	D.1, D.4, D.9	
1.3 Fabric reinforcement, chest strap		2	D.5, D.9	Attach one each to inside left and right outside covers for the chest strap. Use lock stitches on three sides each (see Figure D.9 for locations).
1.4 Fabric reinforcement, belt, and belt loop		2	D.5, D.9	Attach to inside left and right outside covers for the waist belt and belt loop. Use lock stitches on three sides (see Figure D.9 for location).
2 Foam	7 mm thickness, polyethylene (PE) foam, except for one layer as needed to achieve required buoyancy			Layers stacked per Figures D.2 and D.3.
2.1 Front foam insert, left		13 layers	D.2	Trim corners per Figure D.2, except layers B through G.
2.2 Front foam insert, right		13 layers	D.2	Trim corners per Figures D.2, except layers B through G.
2.3 Back foam insert		11 layers	D.3	

Table D.1 (*continued*)

Component	Description	Quality	See Figure	Construction notes
3 Webbing				All cut ends heat-sealed.
3.1 Waist belt webbing	38 mm, black, polypropylene, with easy adjustment and no significant slippage when used with the specified hardware.	1 085 mm cut length	D.1, D.8, D.9	On left side, attach waist belt with female buckle. Tab on the end of belt formed by turning under 40 mm of material twice and stitching 19 mm from the end of the fold with a bar-tack stitch. For location see Figure D.9.
3.2 Belt loop webbing	19 mm, black, polypropylene.	80 mm cut length	D.1, D.6, D.9	Attach webbing to front outside cover with two sets of double bar tack stitches to form a belt loop. For location see Figure D.9.
3.3 Chest strap webbing	19 mm, black, polypropylene.	235 mm and 80 mm cut length	D.1, D.7, D.9	Attach webbing with female buckle to right outside cover. Attach webbing with male buckle to left outside cover. For location see Figure D.9. Tab formed 75 mm from the free end of the male section of chest strap by folding in 'Z' pattern 30 mm apart and stitching 15 mm from the fold with a bar-tack stitch. See Figure D.7.
4 Thread	Generic synthetic	AR		
5 Hardware				
5.1 Buckle	38 mm, plastic (male and female sections)	1	D.1, D.8	Used in waist belt assembly
5.2 Buckle	19 mm, plastic (male and female sections)	1	D.1, D.7	Used in chest strap assembly
5.3 Zipper	350 mm, plastic (zipper chain length)	1	D.1, D.9	Installed to be hidden by cover fabric when closed.
5.4 Zipper	180 mm, plastic separating (zipper chain and box/pin length)	2	D.1, D.9	Installed to be hidden by cover fabric when closed.

Table D.2 — List of dimensions shown in Figure D.2

Dimensions in millimetres

Dimension	Insert layer						
	A	**B**	**C**	**D**	**E**	**F**	**G**
a	140	133	127	120	108	95	83
b	190	184	178	172	165	160	140
c	28	28	28	28	28		

Table D.3 — List of dimensions shown in Figure D.3

Dimensions in millimetres

Dimension	Insert layer				
	A	B	C	D	E
a	310	303	290	275	255
b	165	160	140	120	95
c	3	3	3	3	– 3
R	44	44	44	44	44

Table D.4 — Foam insert specifications

Property	Left front insert	Right front insert	Back insert
Density	(25 ± 5) kg/m^3	(25 ± 5) kg/m^3	(25 ± 5) kg/m^3
Compressive strength at 25 % (ISO 3386-1)	(28 ± 10) kPa	(28 ± 10) kPa	(28 ± 10) kPa
Buoyancy [a, b]	(21 ± 1,2) N	(21 ± 1,2) N	(29 ± 1,2) N

[a] The buoyancy of most foams will change over time with the greatest change occurring in the first several months after manufacture. The exact kind of foam selected will need to be evaluated to determine the amount of additional buoyancy needed at the time of manufacture to achieve the values specified.

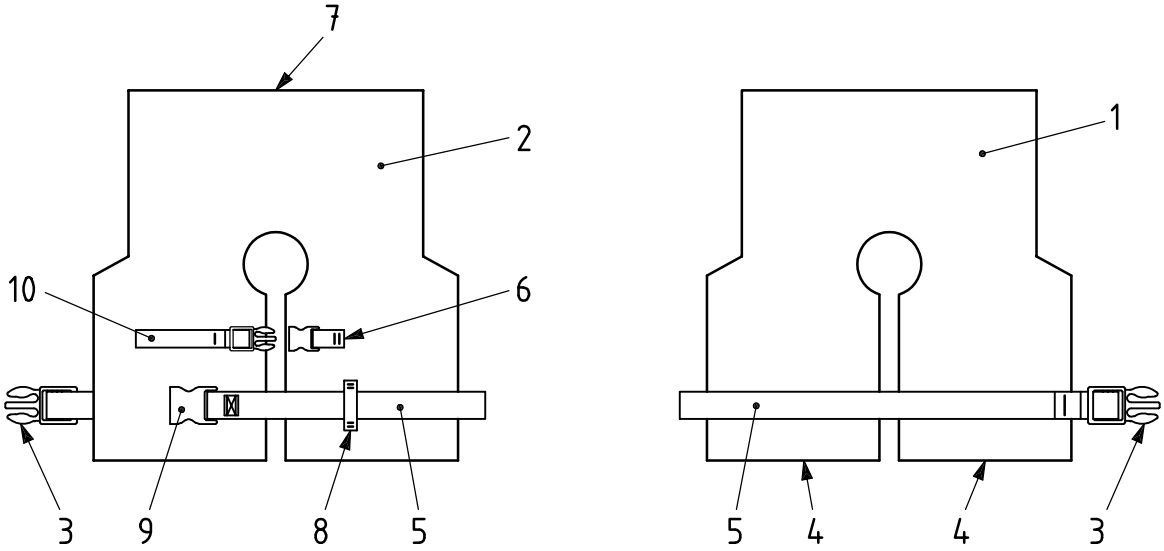
[b] Buoyancy distribution: 59,2 % front ± 1,5 %.

Table D.5 — List of dimensions shown in Figures D.4 to D.9

Dimensions in millimetres

Dimension	Figure D.4	Figure D.5		Figure D.6	Figure D.7	Figure D.8	Figure D.9
		Fabric according to No. 1 in the key	Fabric according to No. 2 in the key				
a	390	75	80	75	90	950 [a]	45
b	195	105	110		40		115
c	85						140
d	220						45
e	245						25
f	241						33
g	482						95
h	260						25
i	490						160

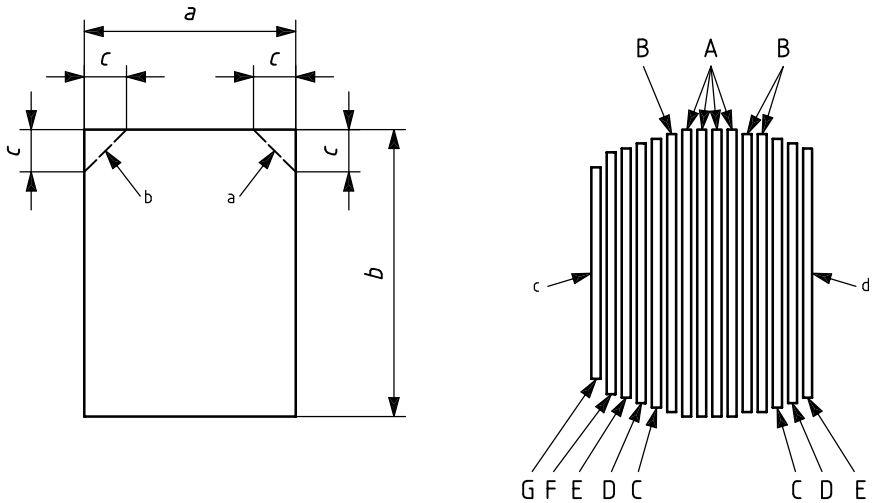
[a] With webbing assembly fully extended.



Key

1 inside cover fabric
2 outside cover fabric
3 adjustable part of closure
4 zippers for access to front right and left foam compartment
5 waist belt
6 fixed part of chest strap
7 zipper for access to back foam compartment
8 belt loop
9 fixed part of closure
10 lock stitch to provide foam compartment separation

Figure D.1 — General arrangement, right side out (outside and inside)



Key

a Trim upper right corner only for left insert layers according to Table D.2.
b Trim upper left corner only for right insert layers according to Table D.2.
c Outside.
d Inside.

Figure D.2 — Front foam inserts (right and left sides)

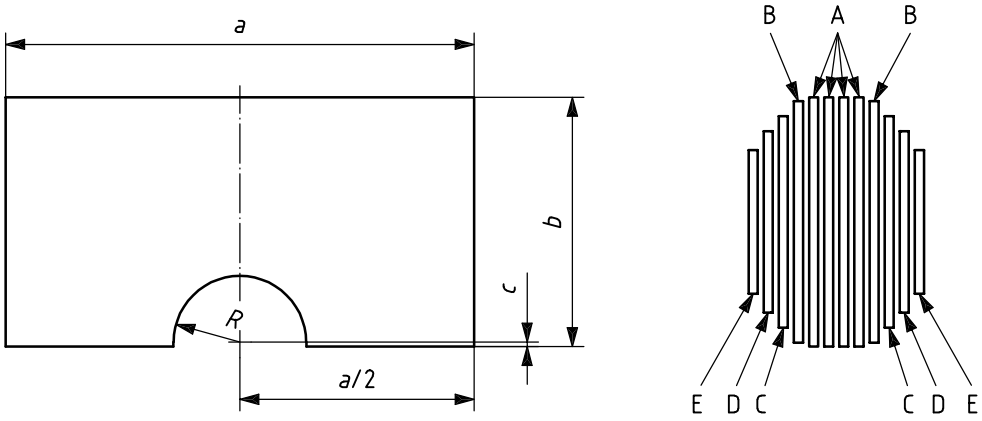


Figure D.3 — Back foam insert

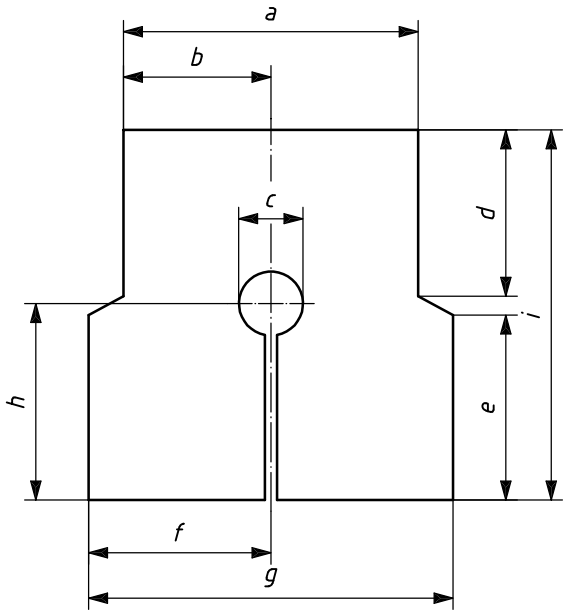
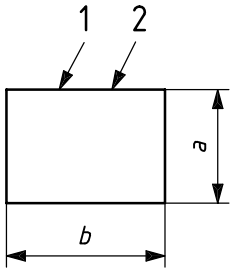


Figure D.4 — Cover cut pattern (outside and inside covers)

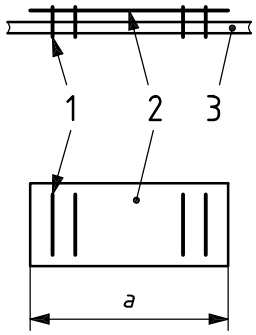


Key

1 fabric reinforcement for chest strap attachments

2 fabric reinforcement for waist belt and belt loop attachments

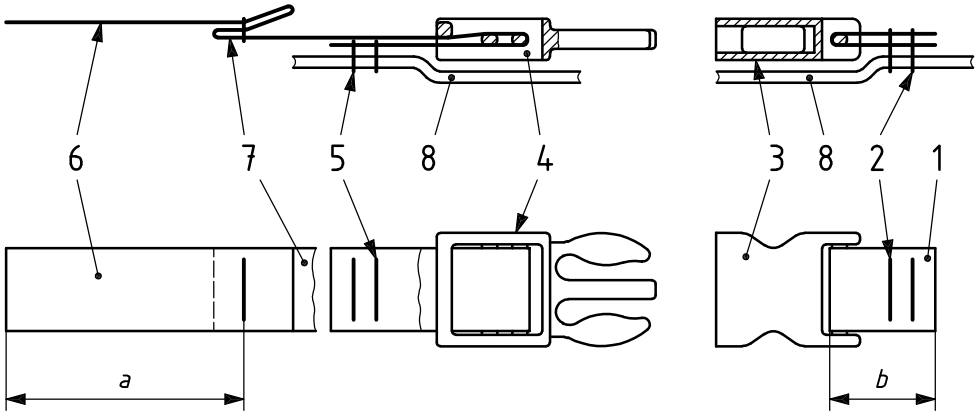
Figure D.5 — Fabric reinforcements



Key

1 bar-tack stitch
2 webbing
3 outer cover and reinforcement (shown on lower view only)

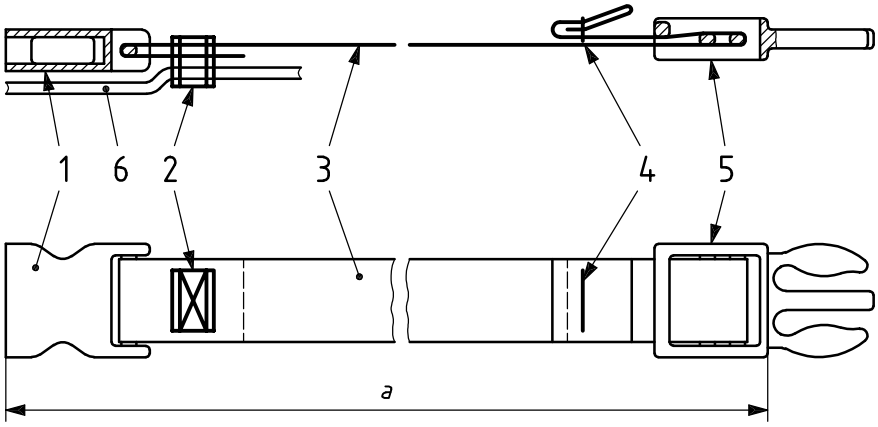
Figure D.6 — Belt loop



Key

1 webbing
2 double bar-tack (or box-x) stitch
3 fixed part of closure
4 adjustable part of closure
5 double bar-tack (or box-x) stitch
6 webbing
7 tab
8 outer cover and reinforcement (shown on lower view only)

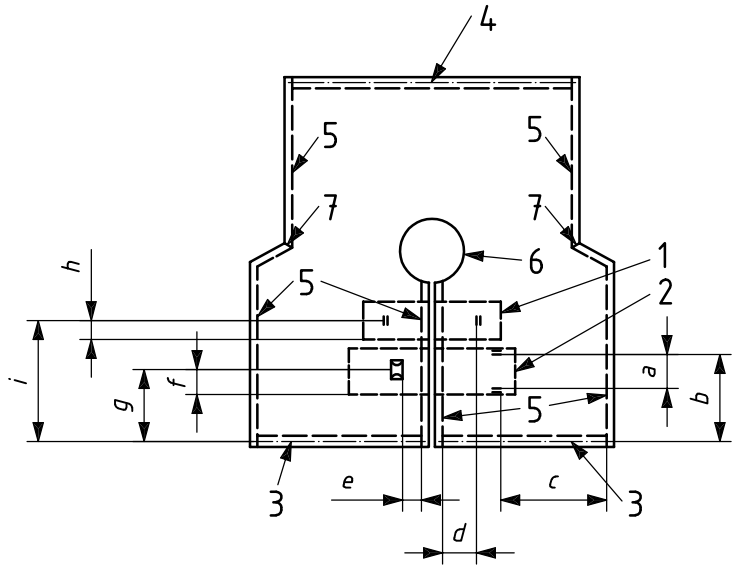
Figure D.7 — Chest strap assembly (adjustable part left and fixed part right)



Key

1 fixed part of plastic closure
2 box-x (or double bar-tack) stitch
3 webbing
4 tab, webbing double-folded and secured with a bar-tack stitch
5 adjustable part of plastic closure
6 outer left cover and reinforcement (shown on lower view only)

Figure D.8 — Waist belt assembly



Key

1 stitching on interior fabric reinforcement for chest strap on right and left sides of outside cover only
2 stitching on interior fabric reinforcement for waist belt and belt loop on right and left sides of outside cover only
3 fabric fold and zipper teeth line of engagement when attached to outside and inside covers
4 fabric fold and zipper teeth line of engagement when attached to outside and inside covers
5 lock-stitch seam (with fabric face to face)
6 lock stitch with 5 mm seam allowance and over-edge stitch (with fabric face to face)
7 after-stitching cut relief

Figure D.9 — Initial assembly (shown right side out, except as noted)

Annex E
(informative)

Child manikins

E.1 General

It has been shown that children of less than 5 years of age find it difficult to don a lifejacket without assistance, and that they do not follow many instructions during lifejacket tests in water. Whilst it is possible to carry out subjective assessments of comfort, head support and airways protection, it is very difficult to make any objective measurements. More importantly, small children do not relax in water (even more so than in adults). A small child will always instinctively lift its ears clear of the water and will usually help to turn itself over if placed in a face-down position. It is therefore very difficult to separate the performance of the lifejacket from the effect of the physical activity of the child. A test such as a drop test cannot be carried out for obvious safety reasons. Any test that places the child at risk is generally regarded as being unethical.

E.2 Choice of manikin for testing

E.2.1 The manikins have thus been developed for the following reasons:

— to limit the use of infants and small children in lifejacket testing;

— to improve safety;

— to improve the objectivity and reproducibility of test procedures used to assess lifejackets designed for infants and children.

E.2.2 The manikins have been designed to test lifejackets intended for small children weighing less than 20 kg.

E.2.3 The appropriate manikin should be selected, fitting within the target mass range of the lifejacket. For example, the 9,4 kg manikin should be used to test a lifejacket designed for infants weighing 5 kg to 10 kg; whilst the 14,5 kg manikin should be used to test a lifejacket designed for children weighing 10 kg to 15 kg.

E.3 Required performance of manikins

Any manikins developed to meet the design specification defined in this annex shall undergo verification trials to demonstrate that the performance of the manikin can mimic the performance and flotation attitudes of a child of similar mass and body density. When tested using a child reference vest, the manikin shall be shown to perform adequately. It shall also be demonstrated that the manikin is capable of providing reproducible test results with acceptable and recorded levels of uncertainty.

E.4 Example of a manikin design specification

Care should be taken to develop manikins with the correct segment density to ensure that the manikins float in a manner that will simulate a small child who is fully relaxed or unconscious in the water. The mass distribution and body segment densities of an example manikin are given in Tables E.1 and E.2.

Table E.1 — Target mass distribution and density of body segments of 14,5 kg manikin

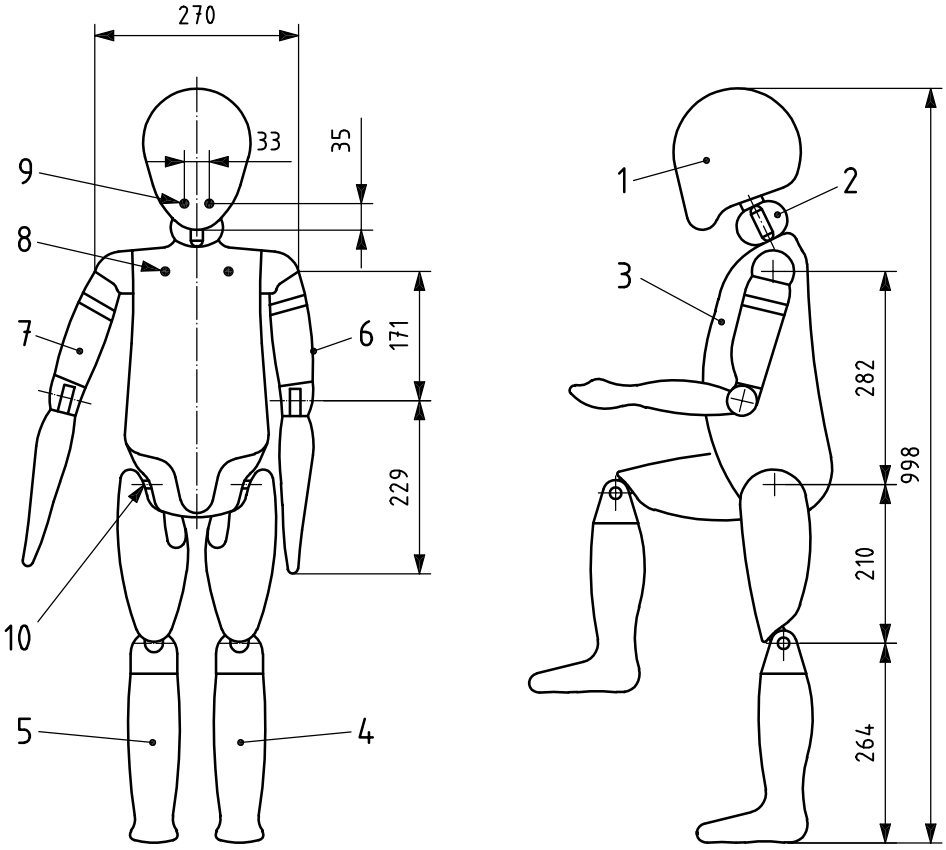
Component	Mass g	Volume cm^3	Density g/cm^3
Head and neck	2 740	2 450	1,118
Torso	6 800	6 545	1,039
Upper leg (×2)	897	834	1,075
Lower leg (×2)	859	803	1,070
Upper arm (×2)	408	382	1,068
Lower arm (×2)	300	285	1,053
Total	**14,5 kg**	**13 603 cm^3**	**1,064 g/cm^3**

Table E.2 — Target mass distribution and density of body segments of 9,4 kg manikin

Component	Mass g	Volume cm^3	Density g/cm^3
Head and neck	2 070	1 888	1,096
Torso	4 780	4 635	1,031
Upper leg (×2)	514	480	1,071
Lower leg (×2)	405	380	1,065
Upper arm (×2)	202	192	1,052
Right lower arm (×2)	153	145	1,055
Total	**9,4 kg**	**8 917 cm^3**	**1,054 g/cm^3**

Figures E.1 and E.2 are scale drawings of the 14,5 kg and 9,4 kg manikins, respectively, showing the key body dimensions.

Dimensions in millimetres

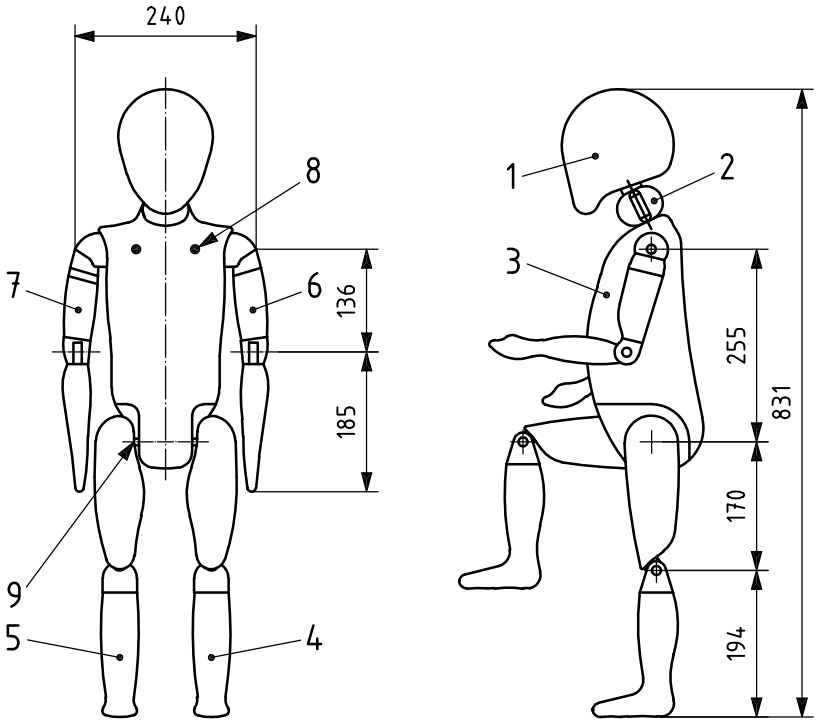


Key

1 head assembly
2 neck assembly
3 torso assembly
4 left leg assembly
5 right leg assembly
6 left arm assembly
7 right arm assembly
8 shoulder fixing pin
9 mouth position pin (yellow)
10 hip fixing pin

Figure E.1 — Scale drawing of 14,5 kg manikin

Dimensions in millimetres



Key

1 head assembly
2 neck assembly
3 torso assembly
4 left leg assembly
5 right leg assembly
6 left arm assembly
7 right arm assembly
8 shoulder fixing pin
9 hip fixing pin

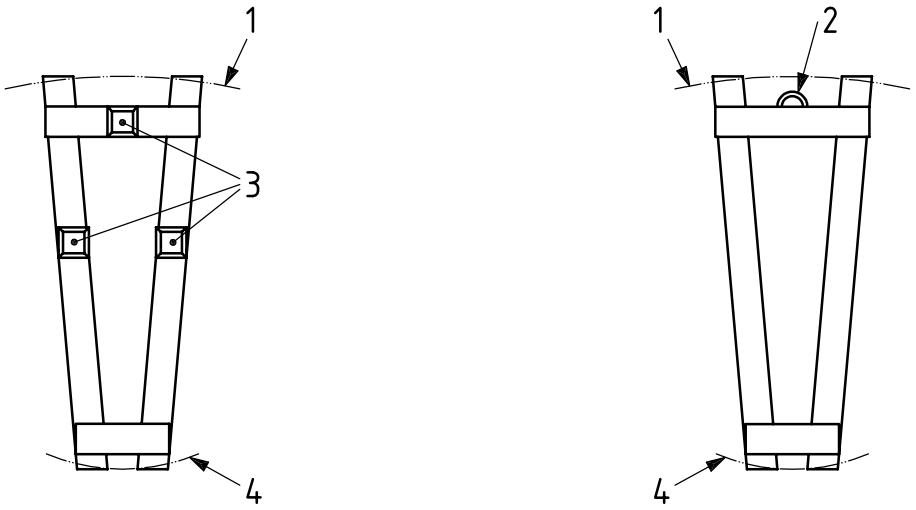
Figure E.2 — Scale drawing of 9,4 kg manikin

E.5 Details of harness and swimsuit requirements

It is recommended that the manikin be dressed in a short-sleeved and short-legged swimsuit to prevent slippage of the lifejacket. This swimsuit shall be made from a knitted fabric containing elastane fibres.

A harness shall be used to allow the manikin to be dropped from a height in the 'forward-bent' position. The harness shall be made from webbing with a D-ring fitted behind the neck at the mid-point between the shoulders. The harness shall be worn over the swimsuit. Care shall be taken to ensure that the performance of the lifejacket, when worn over the harness, is not hindered in any way by the harness and release system.

The harness, see Figure E.3, is constructed from (20 ± 5) mm webbing, running from each shoulder to the crutch. A D-ring ($\leqslant$ 20 mm) is fitted at the back of the neck, allowing connection to a quick-release system.



a) Front view **b) Back view**

Key

1 shoulder of manikin
2 attach line incorporating quick release mechanism, to the D-ring
3 belt clips
4 crutch of manikin

Figure E.3 — Harness

Bibliography

[1] ISO 105-E02, *Textiles — Tests for colour fastness — Part E02: Colour fastness to sea water*

[2] ISO 105-X12, *Textiles — Tests for colour fastness — Part X12: Colour fastness to rubbing*

[3] ISO 9227:1990, *Corrosion tests in artificial atmospheres — Salt spray tests*

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