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Personal flotation devices —

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

Équipements individuels de flottabilité —
Partie 7: Matériaux et composants — Exigences de sécurité et méthodes d'essai

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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 12402-7 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 to 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 7:
Materials and components — Safety requirements and test methods

1 Scope

This part of ISO 12402 specifies the minimum requirements for construction and performance of materials and components of personal flotation devices as well as relevant test methods.

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 31 (all parts), *Quantities and units*

ISO 105-A02, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour*

ISO 105-B02:1994, *Textiles — Tests for colour fastness — Part B02: Colour fastness to artificial light: Xenon arc fading lamp test*

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

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

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

ISO 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 1302, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

ISO 1421:1998, *Rubber- or plastics-coated fabrics — Determination of tensile strength and elongation at break*

ISO 1926, *Rigid cellular plastics — Determination of tensile properties*

ISO 2062, *Textiles — Yarns from packages — Determination or single-end breaking force and elongation at break*

ISO 2411:2000, *Rubber- or plastics-coated fabrics — Determination of coating adhesion*

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*

ISO 4674-1:2003, *Rubber- or plastics-coated fabrics — Determination of tear resistance — Part 1: Constant rate of tear methods*

ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 5470-2:2003, *Rubber- or plastics-coated fabrics — Determination of abrasion resistance — Part 2: Martindale abrader*

ISO 6330, *Textiles — Domestic washing and drying procedures for textile testing*

ISO 7229, *Rubber- or plastics-coated fabrics — Measurement of gas permeability*

ISO 7854:1995, *Rubber- or plastics-coated fabrics — Determination of resistance to damage by flexing*

ISO 9073-4, *Textiles — Test methods for nonwovens — Part 4: Determination of tear resistance*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

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

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

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

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

ISO 12402-5, *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*

ISO 12947-2, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 2: Determination of specimen breakdown*

ISO 13934-1, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13934-2, *Textiles — Tensile properties of fabrics — Part 2: Determination of maximum force using the grab method*

ISO 13937-2, *Textiles — Tear properties of fabrics — Part 2: Determination of tear force of trouser-shaped test specimens (Single tear method)*

ISO 13938-1, *Textiles — Bursting properties of fabrics — Part 1: Hydraulic method for determination of bursting strength and bursting distension*

ISO 13938-2, *Textiles — Bursting properties of fabrics — Part 2: Pneumatic method for determination of bursting strength and bursting distension*

EN 590, *Automotive fuels — Diesel — Requirements and test methods*

EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

CIE publication No. 15.2, *Colorimetry*

ASTM D 412-98, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers —Tension*

ASTM D 471-98, *Standard Test Method for Rubber Property-Effect of Liquids*

ASTM D 882-02, *Standard Test Method for Tensile Properties of Thin Plastic Sheeting*

ASTM D 1683, *Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics*

ASTM D 2061, *Standard Test Methods for Strength Tests for Zippers*

ASTM D 2062, *Standard Test Methods for Operability of Zippers*

ASTM D 5034-95, *Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)*

FTMS 191A, *Federal Test Method Standard*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12402-1 to ISO 12402-5 and the following apply.

3.1
coated fabric
flexible material composed of a textile fabric and an adherent polymeric material

3.2
course
series of successive loops lying crosswise in knitted fabrics, that is, lying at right angles to a line passing through the open throat to the closed end of the loops

3.3
cylinder seal indicator
visual display on an inflation system which provides information regarding the status of the seal on an installed cylinder

3.4
design inflation range
range of buoyancy and pressure, as specified by the manufacturer, to which a chamber is capable of being inflated to provide the intended in-water performance

3.5
weft
yarn running from selvage to selvage at right angles to the warp in woven fabrics

NOTE For knitted fabric, see 3.21.

3.6
filling density
mass of the gas charge for gas-filled cylinders or other inflation-medium containers, in kilograms, divided by the volume of the inflation-medium container, in litres

3.7
foam flotation material
closed-cell (cells not interconnecting) foamed polymeric material

3.8
full inflation
chamber or chambers inflated to any value within the design inflation range

3.9
inflation system
means of inflating one or more chambers to make the PFD buoyant or more buoyant on demand, either actively or passively with respect to the user's action

3.10
initial jaw separation
distance between the bottom of the top clamp and the top of the bottom clamp of a tensile test machine prior to testing

3.11
laminated fabric
layered fabric structure wherein a fabric is combined with a continuous sheet material, either by heat or by an adhesive, in such a way that the identity of the continuous sheet material is retained

3.12
lot number
marking assigned to each group of materials or component produced which incorporates a means of identifying the year and quarter of manufacture (unless provided elsewhere), and provides a means of identifying the production of a particular factory when a manufacturer produces at more than one factory

3.13
multi-eyelet guide
polymeric part designed to be sewn into a PFD and having a series of holes to insert lacing for adjustment of the fit of a PFD

3.14
multi-point status indicator
status indicator which utilizes two or more independent visual display points to communicate inflation system readiness

3.15
polymeric foam coating
coating applied to flotation foam in place of a fabric covering to protect and strengthen the finished PFD

3.16
selvage
uncut edge portion of a fabric

3.17
serviceability
ease with which the inflation system mechanism is properly rearmed

3.18
serviceable
capable of continued use, i.e. exhibits no signs of functional deterioration, broken or deformed hardware, non-functional indicators, blocked or detached oral inflation tube, or detached manual inflator trigger

3.19
single-point status indicator
status indicator which combines all system checks into a single visual display point to communicate inflation system readiness

3.20
status indicator
part or parts of an inflation system which provide user feedback to assist in keeping an inflatable PFD in an armed and ready condition

3.21
wale
column of loops in successive courses in knitted fabrics, which is parallel to the loop axes

3.22
warp
yarn running lengthwise, parallel to the selvage, in a woven fabric

NOTE For knitted fabrics, see 3.2.

3.23
warp test
test which consists of breaking or tearing the warp yarns or course loops

NOTE In the breaking load and seam slippage tests, warp is the long dimension of the sample; in the tearing strength test, warp is the short dimension of the sample.

4 Materials and components

4.1 General

4.1.1 Principles

All structural materials and components of personal flotation devices shall meet the requirements specified in this part of ISO 12402.

It is recommended that

— all test procedures described hereafter will be performed only by third-party test houses which comply with the requirements of ISO/IEC 17025;

— the tests will be performed by experienced test houses familiar with the products specified by ISO 12402 where assessment is subjective. Those tests involving human test subjects shall be witnessed by a test panel of at least three experts familiar with testing and the products specified in ISO 12402.

4.1.2 Sampling

Two samples (one from each end of the range) of materials and components common to a range of products may be presented and the results used to cover the full range of products.

4.1.3 Pass or fail criteria

All required samples shall pass all objective tests for the component or material to meet the requirements of this part of ISO 12402. For any test identified as subjective or which uses human test subjects, because of the high variability between subjects and the difficulty in assessing some subjective measures, a component may be accepted on the basis of the following additional testing. If a component does not completely meet the requirements of a test for a particular measurement or does so but with only one test subject, another two samples or subjects (within similar physical characteristics, if applicable) shall be subjected to the same test and before the same test personnel. Such subjective tests shall be witnessed by a test panel of at least two experts familiar with testing the products specified in the series of ISO 12402 and repeated with three experts if there is any question about the performance observed. If this additional test is still not clearly passed in accordance with this part of ISO 12402, then the component or material shall be deemed to have failed. The test panel should deem that the component or material has passed the test only if it has now fulfilled the test requirements completely.

4.1.4 Units of measurement

Units of measurement shall be in accordance with ISO 31.

4.1.5 Material

4.1.5.1 Non-metallic components and fabrics

Non-metallic components and fabrics shall not be damaged by storage at temperatures of −30 °C to +65 °C.

4.1.5.2 Corrosion of metal components

When tested in accordance with ISO 9227 for a period of 160 h, metal components shall not be significantly affected by corrosion. This shall be tested according to the relevant clauses of this part of ISO 12402.

4.1.5.3 Magnetic properties

No metallic component shall affect a magnetic compass of a type commonly used in small boats by more than 1° when placed 500 mm from the compass.

4.1.5.4 Innocuousness

The foam flotation material shall not contain CFC or HCFC.

4.1.6 Sample conditioning

4.1.6.1 General

Materials and components common to a range of products may be presented as one sample of each item.

Prior to testing, materials and components shall be conditioned.

4.1.6.2 Standard conditioning

a) Except for textile products (i.e., fabric, webbing, thread, tie tape), the applicable number of samples specified in each section shall be conditioned at (23 ± 2) °C and (50 ± 5) % relative humidity for not less than 24 h prior to the tests.

b) For textile products, the samples shall be conditioned according to ISO 139 for not less than 24 h.

c) If it is spelled out that the sample is to be tested under “wet conditions”, the sample shall be soaked for $6^{+\,0,2}_{\ 0}$ h in fresh water, or as specified by the test procedure itself.

4.1.6.3 Temperature cycling

Where required by the test method, the component or sample of fabric shall be conditioned, in its normal storage state, and then immediately exposed for (24,0 ± 0,5) h at a temperature of (−30 ± 2) °C, then for (24,0 ± 0,5) h at a temperature of (65 ± 2)°C. Any damage shall be assessed by visual examination and be reported. The component or sample shall undergo ten cycles.

4.1.6.4 Accelerated weathering

Laboratory exposure of components and fabrics for PFDs to conditions representative of elements found in a severe outdoor environment including light and water shall be conducted by exposing samples in a xenon weathering machine in accordance with ISO 4892-1 and ISO 4892-2 as further defined by the following specifications.

— Exposure: 500 kJ/(m^2 × nm) at 340 nm of UV radiation.

— Sample mounting: mount samples with the face side (the side normally exposed to sunlight in service) toward the light so that the centre of each sample is in the same plane as the perpendicular to the centreline of the light source.

— Irradiance: 0,55 W/m^2 at 340 nm.

— Filters: daylight filters.

— Black panel temperature: (63 ± 2) °C.

— Dry bulb temperature: (42 ± 2) °C.

— Relative humidity: 50 % (during light-only cycle).

— Water temperature: (20 ± 5) °C.

— Test cycles: 102 min of light/18 min of light and continuous water spray/24 min dark and water spray.

4.2 Sewing thread

4.2.1 Construction

Sewing thread shall not contain natural fibres or be monofilament.

4.2.2 Performance

Sewing thread shall comply with the requirements specified in Table 1.

4.2.3 Loop breaking strength

For the loop breaking strength test, the test machine described in ISO 2062 shall be used. Secure both ends of one piece in one clamp of the testing machine so that the length of the loop equals half the total length between the jaws. Pass one end of the second piece through the loop formed by the first, and secure both ends of the second piece in the other clamp of the machine. Separate the clamps at a rate of (300 ± 10) mm/min.

Table 1 — Sewing thread

Property	Exposure	Test method	Number of samples	Sample size [a] mm	Compliance criteria
Single strand breaking	1 Standard conditioning 2 Accelerated weathering according to 4.1.6.4	ISO 2062	5 for each colour for each exposure	1 000 ± 10	For exposure 1, the average breaking strength of five samples shall be at least 25 N. For exposure 2, the average breaking strength of five samples shall retain at least 60 % of the strength determined following standard conditioning. In addition, the average breaking strength of five samples shall be at least 23 N.
Loop breaking strength	Standard conditioning [a]	See 4.2.3	5 (each consisting of two pieces)	500 min.	Average breaking strength of five samples shall be at least 44 N.

[a] Applies to each colour.

4.3 Fabric

4.3.1 General

Only fabrics which are structural to maintain the performance of the product under test shall be tested. Decorative and other fabrics shall not be tested.

4.3.2 Performance

4.3.2.1 Fabric used as drainage material shall comply with all of the applicable fabric requirements. Following weathering according to 4.1.6, the tensile strength shall be measured using the grab method given in ISO 13934-2.

4.3.2.2 Textile woven fabrics shall have an as received tensile strength of at least 400 N, measured using the grab method given in ISO 13934-2.

4.3.2.3 Textile knitted fabrics shall have an as received tensile strength of at least 400 N, measured using the grab method given in ISO 13934-2.

4.3.2.4 Fabrics used in the construction of covers of buoyant compartments, the retention system, and any other component the failure of which would render the PFD non-conformant with this part of ISO 12402, shall comply with the following requirements.

a) Tensile strength for woven fabrics shall be tested according to ISO 13934-2 using the grab method, following conditioning according to 4.1.6, and shall have the strength given in Table 2,

b) Tear resistance of woven fabrics shall be tested according to ISO 13937-2, [tensile speed (100 ± 10) mm/min, with a pretension of 2 N for materials of up to 200 g/m^2, 5 N for materials of over 200 g/m^2 and up to 500 g/m^2, and 10 N for materials of over 500 g/m^2], and shall be not less than 35 N.

4.3.2.5 Fabric shall comply with the acceptance criteria specified in Table 2 when subjected to the tests therein. Separate samples shall be used for each different conditioning exposure.

Table 2 — Fabric

Property	Exposure	Test method	Number of samples	Sample size [a] (mm)	Compliance criteria
Tensile strength (woven fabrics only)	1 Standard conditioning 2 Accelerated weathering according to 4.1.6.4 3 70 h immersion in: 3.1 fuel B according to ASTM D 471-98 or diesel fuel according to EN 590 3.2 IRM 902 oil according to ASTM D 471-98 3.3 0,5 % detergent according to ISO 6330	ISO 13934-2	5 warp and 5 weft for each separate exposure	As specified by test method	Following each separate exposure in 1 and 2, the average of five samples shall be at least 400 N for each direction. Following exposures 2 and 3, the average of five samples shall retain at least 60 % of the strength determined following standard conditioning. Following exposure 2, the average of five samples shall be at least 290 N.
Burst (knitted fabrics only)	1 Standard conditioning 2 Accelerated weathering according to 4.1.6.4 3 70 h immersion in: 3.1 fuel B according to ASTM D 471-98 or diesel fuel according to EN 590 3.2 IRM 902 oil according to ASTM D 471-98 3.3 0,5 % detergent according to ISO 6330	ISO 13938-1 or ISO 13938-2	10 for each separate exposure	130 × 130	Following each separate exposure in 1 and 2, the average of 10 samples shall be at least 800 kPa. Following exposure 3, the average of 10 samples shall retain at least 60 % of the strength determined following standard conditioning.