INTERNATIONAL STANDARD

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Second edition
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 188, *Small craft*, Subcommittee SC 1, *Personal safety equipment*.

This second edition cancels and replaces the first edition (ISO 12402-7:2006), which has been technically revised. It also incorporates the Amendment ISO 12402-7:2006/Amd. 1:2011.

The main changes with respect to the previous edition are as follows:

a) temperature of temperature cycling (4.1.6.3) was changed from (65 ± 2) °C into (60 ± 2) °C;

b) compliance criteria in Table 1, Sewing thread, were changed;

c) requirements for fabrics performance were changed (see 4.3.2 and Table 2);

d) new chromaticity coordinates x and y and luminance factor β for yellow, orange and red non-fluorescent colours of lifejacket material were added (see Table 3);

e) new chromaticity coordinates x and y and luminance factor β for yellow, yellow-orange, orange and orange-red fluorescent colours of lifejacket material were added (see Table 4);

f) compliance criteria of structural webbing (see Table 5) were modified;

g) compliance criteria of structural tie tape (see Table 6) were modified;

h) new subclause “General” to structural lacing was added (see 4.5.1);

i) immersion of zippers, automatic and manual inflation systems in IRM 902 oil was deleted and ambient temperature replaced by (20 ± 2) °C (see Tables 8, 17 and 18);

j) compliance criteria of webbing closures and adjusters were modified (see Table 9);

k) compliance criteria of lacing closures and adjusters were modified (see Table 10);

l) number of samples reduced for density test on foam flotation material (see Table 12);

m) dimensional test for foam flotation material deleted;

n) test method for the compressibility of inherently buoyant material was modified (see 4.8.2.4);

o) compliance criteria of inflation chamber materials were modified (see Table 15).

A list of all parts in the ISO 12402 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 12402 (all parts):2020 deals with personal floatation devices (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 International Standard give a reasonable assurance of safety from drowning to a person who is immersed in water. ISO 12402 (all parts):2020 does not include the following:

— requirements for lifejackets on seagoing ships, which are regulated by the International Maritime Organization (IMO)[1)] under the International Convention for the Safety of Life at Sea (SOLAS);

— throwable devices and flotation cushions.

ISO 12402 (all parts):2020 allows for the buoyancy of a PFD to be provided by a variety of materials or designs, some of which can require preparation before entering the water (e.g. inflation of chambers by gas from a cylinder or blown in orally). 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), which all 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, if automatic operation would result in entrapment, or if 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 the ISO 12402 series:2020 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 (all parts):2020 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. 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 provided by ISO 12402 (all parts):2020 are the following:

— to provide higher levels of support (levels 100, 150, or 275) that generally float the user with greater water clearance, when required for increasingly severe conditions; 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 accommodate the sometimes conflicting needs of reliability and durability, in-water performance, and continuous wear;

1) The International Maritime Organization (IMO) is an institution with domicile in London issuing regulations which are then published as laws by its Member States.

— 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 PFDs 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 need to be secure when worn, in order to provide positive support in the water and to allow users to swim or actively assist themselves or others. The PFD selected ensures 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) can alter the performance of the PFD. Users, owners and employers need to ensure that this is taken into account when selecting a PFD. Similarly, it is possible that PFDs do not perform as well in extremes of temperature, although meeting ISO 12402 (all parts):2020 requirements. PFDs can also be affected by other conditions of use, such as chemical exposure and welding, and can require additional protection to meet the specific requirements of use. Taking a PFD into such conditions necessitates the assurance that the PFD will not be adversely affected. ISO 12402 (all parts):2020 also allows a PFD to be an integral part of a safety harness designed to conform to ISO 12401:2009, 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 expected to conform to ISO 12402 (all parts):2020.

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 use. 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 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 impair 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.

The characteristics of the product properties, alternative choices and the limitations to normal use are to be explained to potential buyers by manufacturers and distributors of PFDs prior to purchase.

Similarly, it is advised that regulators regarding the use of these garments 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 expected consequences. Requirements and recommendations for the correct selection and application of PFDs are given in ISO 12402-10:2020.

Personal flotation devices —

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

1 Scope

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 105-A02:1993, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour*

ISO 105-E02:2013, *Textiles — Tests for colour fastness — Part E02: Colour fastness to sea water*

ISO 105-X12:2016, *Textiles — Tests for colour fastness — Part X12: Colour fastness to rubbing*

ISO 139:2005/Amd 1:2011, *Textiles — Standard atmospheres for conditioning and testing*

ISO 188:2011, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 846:2019, *Plastics — Evaluation of the action of microorganisms*

ISO 1302:2002, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

ISO 13688:2013, *Protective clothing — General requirements*

ISO 1421:2016, *Rubber- or plastics-coated fabrics — Determination of tensile strength and elongation at break*

ISO 1926:2009, *Rigid cellular plastics — Determination of tensile properties*

ISO 2062:2009, *Textiles — Yarns from packages — Determination of single-end breaking force and elongation at break using constant rate of extension (CRE) tester*

ISO 2411:2017, *Rubber- or plastics-coated fabrics — Determination of coating adhesion*

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

ISO 4674-1:2016, *Rubber- or plastics-coated fabrics — Determination of tear resistance — Part 1: Constant rate of tear methods*

ISO 4892-1:2016, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

ISO 4892-2:2013, *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 6330:2012, *Textiles — Domestic washing and drying procedures for textile testing*

ISO 7229:2015, *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 9073-4:1997, *Textiles — Test methods for nonwovens — Part 4: Determination of tear resistance*

ISO 9227:2017, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 12402-2:2020, *Personal flotation devices — Part 2: Lifejackets, performance level 275 — Safety requirements*

ISO 12402-3:2020, *Personal flotation devices — Part 3: Lifejackets, performance level 150 — Safety requirements*

ISO 12402-4:2020, *Personal flotation devices — Part 4: Lifejackets, performance level 100 — Safety requirements*

ISO 12402-5:2020, *Personal flotation devices — Part 5: Buoyancy aids (level 50) — Safety requirements*

ISO 12402-6:2020, *Personal flotation devices — Part 6: Special purpose lifejackets and buoyancy aids — Safety requirements and additional test methods*

ISO 13934-1:2013, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13934-2:2014, *Textiles — Tensile properties of fabrics — Part 2: Determination of maximum force using the grab method*

ISO 13937-2:2000, *Textiles — Tear properties of fabrics — Part 2: Determination of tear force of trouser-shaped test specimens (Single tear method)*

ISO 13938-1:2019, *Textiles — Bursting properties of fabrics — Part 1: Hydraulic method for determination of bursting strength and bursting distension*

ISO 13938-2:2019, *Textiles — Bursting properties of fabrics — Part 2: Pneumatic method for determination of bursting strength and bursting distension*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

ISO 80000-2:2019, *Quantities and units — Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*

ISO 80000-3:2019, *Quantities and units — Part 3: Space and time*

ISO 80000-4:2019, *Quantities and units — Part 4: Mechanics*

EN 590:2013/Amd 1:2017, *Automotive fuels — Diesel — Requirements and test methods*

EN 10088-1:2014, *Stainless steels — Part 1: List of stainless steels*

CIE publication No, 15.2, Colorimetry

ASTM D412-16, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers —Tension*

ASTM D471-16, *Standard Test Method for Rubber Property-Effect of Liquids*

ASTM D412-92, *Tensile Strength Properties of Rubber and Elastomers*

ASTM D2061-07, *Standard Test Methods for Strength Tests for Zippers*

ASTM D2062, *Standard Test Methods for Operability of Zippers*

ASTM D882-12, *Standard Test Method for Tensile Properties of Thin Plastic Sheeting*

FTMS 191A, Federal Test Method Standard

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

NOTE Users of this document are encouraged to consult the Online browsing platform (OBP) for the terms and definitions given in ISO 12402-2:2020 to ISO 12402-6:2020.

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

3.2
cylinder seal indicator
visual display on an *inflation system* (3.8) which provides information regarding the status of the seal on an installed cylinder

3.3
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

3.4
weft
yarn running from *selvage* (3.14) to selvage at right angles to the *warp* (3.18) in woven fabrics

Note 1 to entry: For knitted fabric see 4.3.2.3.

3.5
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

3.6
foam flotation material
closed-cell (cells not interconnecting) foamed polymeric material

3.7
full inflation
chamber or chambers inflated to any value within the *design inflation range* (3.3)

3.8
inflation system
means of inflating one or more chambers to make the PFD buoyant or more buoyant on demand, either actively or passively of the user's action

3.9
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

3.10
fabric-laminated foam
layered fabric structure wherein a fabric is combined with a continuous sheet of foam flotation material, either by heat or by an adhesive in such a way that the identity of the continuous sheet material is retained

3.11
multi-eyelet guide
polymeric part designed to be sown into a PFD and having a series of holes to insert lacing for adjustment of the fit of a PFD

3.12
multiple-point status indicator
status indicator (3.17) which utilises two or more independent visual display points to communicate *inflation system* (3.8) readiness

3.13
polymeric foam coating
coating applied to flotation foam in place of a fabric covering to protect and strengthen the finished PFD

3.14
selvage
uncut edge portion of a fabric

3.15
serviceability
ease with which the *inflation system* (3.8) mechanism is properly rearmed

3.16
single-point status indicator
status indicator (3.17) which combines all system checks into a single visual display point to communicate *inflation system* (3.8) readiness

3.17
status indicator
part or parts of an *inflation system* (3.8) which provide user feedback to assist in keeping an inflatable PFD in an armed and ready condition

3.18
warp
yarn running lengthwise, parallel to the *selvage* (3.14), in a woven fabric

Note 1 to entry: For knitted fabrics see 4.3.2.3.

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 document.

The human subject performance tests shall be witnessed by a test panel of at least 2 experts familiar with testing and with 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 test 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 experience of observing (or conducting under the supervision of a qualified observer) the specific test on at least 3 occasions.

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 submitted and the results used to cover the full range of products.

Unless otherwise specified by the test method, the sampling of components shall be representative of the production.

4.1.3 Pass or fail criteria

4.1.3.1 All required samples shall pass all objective tests for the component or material to meet the requirements of this document.

4.1.3.2 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 (with 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 ISO 12402:2020 series 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 document, 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 80000-1:2009, ISO 80000-2:2019, ISO 80000-3:2019 and ISO 80000-4:2019.

4.1.5 Material

4.1.5.1 Non-metallic components and fabrics

Non-metallic components and fabrics shall not be damaged when tested in accordance with the relevant Tables of this document.

4.1.5.2 Corrosion of metal components

When tested in accordance with ISO 9227:2017 for a minimum of 160 h, metal components shall not be significantly affected by corrosion as specified in the relevant Tables of this document.

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 according to ISO 12402-9:2020, 5.4.

4.1.5.4 Innocuousness

Innocuousness material shall comply with ISO 13688:2013, 4.2.

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 139:2005/Amd 1:2011 for not less than 24 h.

c) If it is specified 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 ± 0,5) h at a temperature of (–30 ± 2) °C, then for (24 ± 0,5) h at a temperature of (60 ± 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 lifejackets 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 4892-1:2016 and ISO 4892-2:2013 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 where they contribute to the structural strength of the lifejacket.

4.2.3 Loop breaking strength

For the loop breaking strength test, the test machine described in ISO 2062:2009 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	Requirement[b]
Single strand breaking	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	ISO 2062:2009	5 for each colour for each exposure	1 000 ± 10	For exposure 1, the breaking strand strength shall be at least 25 N. For exposure 2, the breaking strength shall be at least 15 N. Results shall be given as average of the five samples.
Loop breaking strength	Standard conditioning[a]	4.2.3	5 (each consisting of two pieces)	500	The loop breaking strength shall be at least 44 N. Results shall be given as average of the five samples.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For compliance see 4.1.3.

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 13934-2:2014.

4.3.2.2 Textile woven fabrics shall have an as-received tensile strength as specified in Table 2, measured using the grab method given in ISO 13934-2:2014.

4.3.2.3 Textile knitted fabrics shall have an as-received burst strength as specified in Table 2, measured using the method given in ISO 13938-1:2019 or ISO 13938-2:2019.

4.3.2.4 Fabrics used in the construction of covers of buoyant compartments, the ride-up prevention system, and any other component the failure of which would render the lifejacket non-conformant with this document, shall comply with the requirements of Table 2 when tested according to the standards specified in Table 2.

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	Requirement[f]
Tensile strength (woven fabrics only)	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017[b] 4) 70 h immersion in 0,5 % detergent[c] according to ISO 6330:2012	ISO 13934-2:2014, except that jaw breaks may be included in the average results	5 warp and 5 weft for each separate exposure	As specified by test method	Following exposure 1, the tensile strength shall be at least 400 N for each direction. Following each separate exposure 2 and 3, the tensile strength shall be at least 260 N. Results shall be given as average of the five samples.
Bursting strength (knitted fabrics only)	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017[b] 4) 70 h immersion in 0,5 % detergent[c] according to ISO 6330:2012	ISO 13938-1:2019 or ISO 13938-2:2019	6 for each separate exposure	130 × 130	Following exposure 1, the bursting strength shall be at least 800 kPa. Following each separate exposure in 2 and 3, the bursting strength shall be at least 480 kPa. Results shall be given as average of the six samples.
Tearing strength (woven fabrics only)	Standard conditioning	ISO 13937-2:2000	5 warp 5 weft	50 × 200	The tearing strength shall be at least 25 N for each direction. Results shall be given as average of the five samples.
Yarn slippage (woven fabrics only)	Standard conditioning	4.3.2.1	5 warp 5 weft	100 × 150	The yarn slippage shall be at least 220 N. Results shall be given as average of the five samples.
Openness of weave[d]	Standard conditioning	4.3.2.2			The openness of weave shall not exceed 20 %.

Table 2 *(continued)*

Property	Exposure	Test method	Number of samples	Sample size[a] mm	Requirement[f]
Adhesion strength[e]	Standard conditioning	ISO 2411:2017	2 warp and 2 weft or 5 warp and 5 weft	50 × 200 or 75 × 200	The coating adhesion shall be at least 7 N/cm.

[a] Applies to each colour except for fabrics related to lifejackets complying with ISO 12402-5:2020 where a minimum of one colour shall be tested.

[b] Exposure tests to be based on typical fuels used in the intended area of application.

[c] ECE non phosphate detergent.

[d] Applies to external cover fabrics only; does not apply to gusset, lining, or drainage fabric.

[e] Applies only to coated fabric with a coating of 185 g/m^2 or more and where the base fabric or scrim does not comply with the applicable strength requirements when fabric is uncoated.

[f] For compliance see 4.1.3.

4.3.2.6 Yarn slippage (woven fabrics only)

The warp samples specified in Table 2 shall be cut with the long dimension parallel to the warp yarns, and weft samples shall be cut with the long dimension parallel to the weft yarns. No two warp samples shall contain the same warp yarns and no two weft samples shall contain the same weft yarns. No sample shall include selvage.

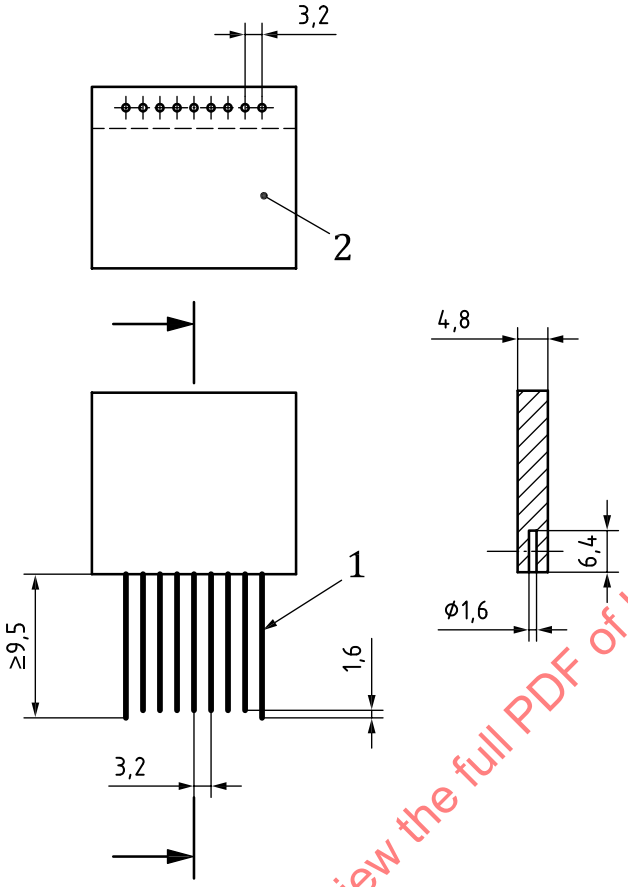
The narrow end of the sample shall be inserted approximately 5 mm into the nine-hole spacer illustrated in Figure 1 and centred. A nine-needle bit shall be aligned with the holes in the chuck so that the smooth side of the needles faces the 5 mm edge of the sample. The needles shall be forced through the fabric past the scarf joint so that the fabric lies against the blade of the needles.

The tensile machine shall be a constant-rate-of-traverse (CRT) or constant-rate-of-extension (CRE) machine.

The tensile machine shall be equipped with clamps having front jaws 25 mm × 25 mm and back jaws 25 mm × 38 mm or more wider. The nine-hole chuck shall be centred and clamped in the upper jaws of the machine so the sample hangs lengthwise. The holes in the chuck shall be perpendicular to the direction of pull. The fabric shall be clamped to the lower jaws of the machine. Separation between the holes in the chuck and the top of the jaws shall be 65 mm. The yarns shall be parallel to the direction of pull. The jaws shall then be separated at a rate of (300 ± 10) mm/min.

The maximum force required to cause rupture shall be recorded.

Dimensions in millimetres



Key

1 Singer® thin ball-point needles (size 18)[a,b]

2 nine-hole spacer

a The needles used have a conventional cylindrical profile (not U-bladed) and standard scarf. The grooves of the needles all face in the same direction, perpendicular to the plane formed by the nine needles.

b Singer® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Figure 1 — Nine-needle apparatus

4.3.2.7 Openness of weave

The openness of weave, see Table 2, shall be determined using a full width sample at least 1 000 mm long. Five separate measurements shall be taken across the width of the roll. For each measurement, a 650 mm^2 area shall be marked on the fabric. No measurement shall be within 25 mm of the selvage edge.

In the area of the marked fabric material, the size of each opening shall be measured using an optical comparator with a magnification of 5×. Openings on the edge of a 650 mm^2 area shall be counted as one whole opening only if more than 50 % of the opening is inside the marked square.

The openness of the weave shall be calculated according to Formula (1):

$$\theta = \frac{100 \times S}{n} \tag{1}$$

where

θ is the openness of weave;

S is the total surface area of openings, in mm^2;

n is the number of 650 mm^2 areas.

4.3.3 Colour

4.3.3.1 The colour of the exposed portions (excluding components such as webbing, zips and other fittings) of a lifejacket when deployed in normal floating position shall be in the colour range from yellow to red; the chromaticity for non-fluorescent colours shall lie within one of the areas defined in Table 3 and the luminance factor shall exceed the corresponding minimum in Table 3. The chromaticity coordinates and the minimum luminance factor for fluorescent colours shall comply with Table 4.

4.3.3.2 The colour of the material samples shall be measured with the procedures defined in CIE publication No. 15.2 with polychromatic illumination D_{65}, 45/0 geometry and 2° standard observer. The specimen shall have a black underlay with reflectance of less than 0,04. The specimens shall be conditioned for at least 24 h at (20 ± 2) °C and (65 ± 5) % relative humidity. If the test is carried out in other conditions, the test shall be conducted within 5 min after withdrawal from the conditioning atmosphere.

A tolerance of ±5 % shall be allowed in the x- and y-chromaticity coordinates expressed in Table 3 and Table 4.

4.3.3.3 The colour fastness (dry and wet) of lifejacket material, when determined in accordance with ISO 105-A02:1993, shall be resistant to rubbing (wet and dry) when tested in accordance with ISO 105-X12:2016 to at least step 4, and to salt water when tested in accordance with ISO 105-E02:2013 to at least step 4.

Table 3 — Chromaticity coordinates *x* and *y* and luminance factor β for yellow, orange and red non-fluorescent colours of lifejacket material

Colour	Chromaticity coordinates		Luminance factor
	x	*y*	β
Yellow	0,389	0,610	>0,35
	0,320	0,490	
	0,405	0,400	
	0,500	0,500	
Orange	0,500	0,500	>0,25
	0,405	0,400	
	0,470	0,330	
	0,600	0,400	
Red	0,600	0,400	>0,15
	0,470	0,330	
	0,525	0,270	
	0,700	0,300	

Table 4 — Chromaticity coordinates *x* and *y* and luminance factor *β* for yellow, yellow-orange, orange and orange-red fluorescent colours of lifejacket material

Colour	Chromaticity coordinates		Luminance factor
	x	*y*	*β*
Fluorescent yellow	0,380	0,610	>0,60
	0,320	0,490	
	0,370	0,440	
	0,440	0,550	
Fluorescent yellow-orange	0,440	0,550	>0,50
	0,370	0,440	
	0,420	0,390	
	0,505	0,490	
Fluorescent orange	0,505	0,490	>0,40
	0,420	0,390	
	0,460	0,350	
	0,575	0,425	
Fluorescent red-orange	0,575	0,425	>0,30
	0,460	0,350	
	0,488	0,320	
	0,630	0,360	
Fluorescent red	0,630	0,360	>0,20
	0,488	0,320	
	0,525	0,280	
	0,695	0,300	

4.4 Structural webbing and tie tape

4.4.1 General

Structural webbing and tie tape shall comply with this document when subjected to the tests described in Table 5 and Table 6.

If the component has no influence on the in-water performance test or the load test, it can be considered to be a non-structural component.

4.4.2 Torsional stiffness

Three samples shall be used. The samples specified in Table 6 shall be laid flat on a hard surface, straight, and not under tension. One end of the sample shall be marked as the reference end. Marks are to be placed on the sample 32 mm and 1 000 mm from the reference end.

The reference end of the sample shall be held in a clamping surface by taking the end of the sample at the reference end and folding it over until the end is even with the mark drawn 32 mm from the reference end. The reference end shall then be placed in a fabric clamp in accordance with the test methods for tensile strength and elongation of textile fabrics specified in ISO 13934-1:2013, centred and perpendicular to the clamp bars.

The end of the sample opposite the reference end shall be placed in a clamp. The clamping surface area shall be 12,5 mm × 115 mm and the jaws shall not be padded. The end of the sample shall be placed in

the jaws of the clamp so that the 1 000 mm mark is even with the outside bottom edge of the larger jaw of the clamp. The distance between the fabric clamp and the upper jaw shall be 880 mm.

The clamp shall then be mounted so that the sample hangs freely down with the clamps parallel to each other.

The fabric clamp shall then be rotated five complete turns clockwise and released. After the release from the fabric clamp, the sample winds itself back up counter-clockwise. The fabric clamp shall be stopped immediately when the starting position is reached. The time from which the strip was let go until the twisting motion first stopped shall be recorded. For tie-tape material that has an unsymmetrical weave, the procedure shall then be repeated with the sample rotated counter-clockwise.

Table 5 — Structural webbing

Property	Exposure	Test method	Number of samples[a]	Sample length mm	Requirement[b]
Tensile strength	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	ISO 13934-1:2013	5 for each separate exposure	≥300	Following exposure 1, the tensile strength shall be at least 1 600 N. Following exposure 2, the tensile strength shall be at least 960 N. Results shall be given as average of the five samples.
[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested. [b] For compliance see 4.1.3.					

Table 6 — Structural tie tape

Property	Exposure	Test method	Number of samples[a]	Sample length mm	Requirement[b]
Tensile strength	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	ISO 13934-1:2013	5 for each separate exposure	≥300	Following exposure 1, the tensile strength shall be at least 890 N. Following exposure 2, the tensile strength shall be at least 530 N. Results shall be given as average of the five samples.
Torsional stiffness	Standard conditioning	4.4.2	5	1 200	The torsional stiffness shall be not less than 5 s.
[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested. [b] For compliance see 4.1.3.					

4.5 Structural lacing

4.5.1 General

If the component has no influence on the in-water performance test or the load test, it can be considered to be a non-structural component.

4.5.2 Construction

Structural lacing shall be at least 3 mm in diameter or 6 mm in width.

4.5.3 Performance

Structural lacing shall comply with the acceptance criteria specified in Table 7 when subjected to the tests specified in this table.

Table 7 — Structural lacing

Property	Exposure	Test method	Number of samples[a]	Sample length mm	Requirement[b]
Tensile strength	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	ISO 13934-1:2013	5 for each separate exposure	≥300	Following exposure 1, the tensile strength shall be at least 530 N. Following exposure 2, the tensile strength shall be at least 320 N. Results shall be given as average of the five samples.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For compliance see 4.1.3.

4.6 Structural zippers

4.6.1 Construction

A zipper pull shall be at least 24 mm long. Projections (i.e. raised material) on the end of the zipper pull shall be provided to make the zipper pull easier to grasp.

When the pin is properly seated for closing the zipper, the retainer of a zipper shall engage with the separable pin and the slider shall engage the chain.

The slider of the zipper shall be of the automatic locking type.

4.6.2 Performance

4.6.2.1 General

Zippers shall comply with the acceptance criteria specified in Table 8 when subjected to the tests specified in this table.

4.6.2.2 Operability force test

For each set of six samples (see Table 8), three shall be used to determine the force required to open the zipper, and three shall be used to determine the force required to close the zipper. Samples for opening force shall be closed for conditioning. Samples for closing force shall be open (separated) for conditioning. Tests shall be conducted on the slider and on the moveable retainer, when provided.

Table 8 — Zippers

Property	Exposure	Test method	Number of samples[a]	Sample length mm	Requirement[f]
Operability force	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[b,c] 3) 70 h immersion in 0,5 % detergent[d] according to ISO 6330:2012 4) 720 h of salt spray according to 4.1.5.2[e] 5) Accelerated weathering according to 4.1.6.4	ASTM D2062	Six for each separate exposure	150	Following each separate exposure 1 to 5, the operability force exerted to open or close the zipper shall not be greater than 65 N.
Cross-wise strength	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[b,c] 3) 70 h immersion in 0,5 % detergent[d] according to ISO 6330:2012 4) 720 h of salt spray according to 4.1.5.2[e] 5) Accelerated weathering according to 4.1.6.4	4.6.2.3	Samples used in the operability force tests	150	Following exposure 1, the crosswise strength shall be not less than: a) 220 N for the top (including slider); b) 220 N for the chain (crosswise); and c) 130 N for the separating unit (crosswise). Following exposures 2 to 4, the crosswise strength shall be at least: a) 130 N for the top (including slider); b) 130 N for the top (for the chain (crosswise); and c) 80 N for the separating unit (crosswise).

Table 8 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Sample length mm	Requirement[f]
					Following exposure 5 the cross wise strength shall be at least: a) 90 N for the top (including slider); b) 90 N for the top (for the chain (crosswise); and c) 50 N for the separating unit (crosswise). Results shall be given as average of the six samples.
Resistance to pull-off of slider pull	Standard conditioning	ASTM D 2061-07	3	150	The pull-and-slider zipper assembly shall not dislodge when subjected to a force of 180 N.
Resistance to twist of pull and slider	Standard conditioning	ASTM D 2061-07	4 (2 for each direction)	150	The pull and slider shall resist a force of 0,50 Nm torsional stress without significant deformation or rupture.
Holding strength of slider lock	Standard conditioning	ASTM D 2061-07	3	150	The locking mechanism shall remain locked when subjected to a force of 20 N and the slider shall be operable.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] Samples are to be blotted dry to remove surface moisture and are to rest for 30 min at (20 ± 2) °C prior to the operability force and strength tests.

[c] Exposure tests to be based on typical fuels used in the intended area of application.

[d] ECE non phosphate detergent.

[e] Applies to zippers employing metallic parts, except those of stainless steel or equivalent corrosion-resistant metals.

[f] For compliance see 4.1.3.

4.6.2.3 Crosswise strength test

The same samples subjected to the operability force test are to be used. The zippers are to be closed for these tests.

The following tests are to be conducted in accordance with the methods for strength tests for zippers described in ASTM D2061-07:

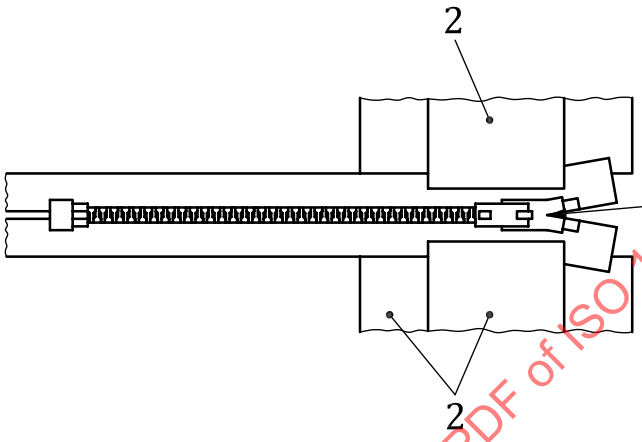
a) for the chain (crosswise);

b) for a separating unit (crosswise) or for a bottom stop holding (crosswise).

The test shall be conducted at the top of the zipper including slider, and at the bottom of the zipper when a moveable retainer (second slider) is used.

The apparatus used for the strength test at the top of the zipper including the slider, and for the test at the bottom of the zipper when a moveable retainer (second slider) is used, shall be as described in ASTM D2061-07.

The tapes of each zipper shall be mounted in the clamps of the tension machine as illustrated in Figure 2, with the edges of the jaws parallel to and approximately 3 mm from the sides of the slider. The slides shall be positioned so that the exposed end of the slider is aligned with the sides of the front jaws as illustrated in Figure 2. The load shall be applied until the slider comes apart, until the tape breaks or until some other kind of malfunction occurs. The maximum load to obtain rupture shall be recorded.



Key

1 slider

2 testing machine clamp

Figure 2 — Crosswise strength test at the top of the zipper (including slider)

4.7 Hardware

4.7.1 Webbing closures and adjusters

4.7.1.1 Construction

Structural closures and adjusters, such as buckles, slide adjusters, snap hooks, D rings, and hook-and-eye clasps shall comply with Table 9 when subjected to the tests specified in this table.

4.7.1.2 Performance

4.7.1.2.1 Tensile strength

Each assembly shall consist of the conditioned sample with two lengths of 150 mm of unconditioned webbing for lifejackets with specifications as they are for use.

The tester used shall be a constant-rate-of-extension (CRE) tensile test machine, as described in the specification for tensile testing machines for textiles, with a rate of extension of (300 ± 10) mm/min. The front and back jaws of the clamps shall be at least as wide as the webbing being used on the samples. The gauge length shall be $\left(50^{+5}_{0}\right)$ mm longer than the length of the sample being tested.

The sample shall be mounted in the tensile machine by securing each length of webbing in opposite clamps so that the sample is centred between the clamps both vertically and horizontally. For the end of the sample in which friction adjustment of the webbing is possible, only the end of that piece of webbing which results in the binding of the webbing to the hardware when under load shall be secured to the

clamps. The clamps shall be separated until breakage, disengagement or webbing slippage in excess of 75 mm occurs. The maximum value (breaking load) to result in failure shall be recorded.

4.7.1.2.2 Strength/slippage

4.7.1.2.2.1 General

A straight-line pull on the lifejacket hardware in combination with webbing shall be performed using the fixed straight-length method or the loop assembly method. This test shall be conducted with webbing, except for the highest-percentage-loss conditioning identified in the tensile strength test, for which only unconditioned webbing shall be used.

The lengths of webbing shall be connected to opposite sides of the hardware according to the routing method recommended by the hardware manufacturer. One length of the webbing shall be attached to a hoist and the other shall be attached to a weight according to Table 9.

A pre-load of (4,5 ± 0,9) kg shall be applied and the webbing shall be marked at the bottom of the adjustable end of the hardware to allow for measurement of slippage after the test. The remainder of the applicable load shall be applied for the required duration. The load shall then be removed and the webbing remarked at the bottom of the hardware. The distance between the marks shall be measured to the nearest 1,0 mm to determine the extent of slippage.

Table 9 — Webbing closures and adjusters

Property	Exposure	Test method	Number of samples[a]	Requirement[i]
Tensile strength	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[b,g] 3) 70 h immersion in 0,5 % detergent[h] according to ISO 6330:2012 4) (70 ± 2) °C for 7 days[b] 5) (−30 ± 2) °C for 24 h[c] 6) 720 h of salt spray according to 4.1.5.2 7) Fatigue[d] 8) Accelerated weathering according to 4.1.6.4	4.7.1.2.1	5 for each separate conditioning	Following exposure 1: a) the tensile strength shall be at least 890 N; or b) where intended for use in meeting the lifejacket horizontal load test requirement for level 150 N and 275 N, the tensile strength shall be at least 1 600 N; c) where hardware is intended for use in meeting the lifejacket horizontal load test requirement for level 100 N or for use in lifejackets, buoyancy aids and flotation suits as single load-bearing closure, the tensile strength shall be at least 1 000 N Buckles that are intended to be used on lifejackets requiring a lifting loop to be fitted also need to be capable of meeting the requirements when the lifejacket is tested according to ISO 12402-9:2020, 5.5.5 (lifting loop test).

Table 9 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Requirement[i]
				Following each separate exposures 2 to 8: a) the minimum strength shall be at least 530 N; or b) where hardware is intended for use in meeting the lifejacket horizontal load test requirement for level 150 N and 275 N as single load-bearing closure, the tensile strength shall be at least 960 N; c) where hardware is intended for use in meeting the lifejacket horizontal load test requirement for level 100 N, or for use in lifejackets, buoyancy aids or flotation suits as single load-bearing closure, the tensile strength shall be at least 600 N.
Strength/ slippage	1) Standard conditioning 2) 2 min water soak[e] 3) The same exposure as tensile strength exposure that resulted in greatest percent strength lost[d]	4.7.1.2.2	5 for each separate exposure	For exposures 1 to 3, each sample shall support without breaking, distorting, or slipping more than 25 mm load of: a) 890 N[f]; b) 1 600 N for 30 min where hardware is intended for use in meeting the lifejacket horizontal load test requirement for 150 N and 275 N for lifejackets, or for 1 000 N for 30 min for 100 N lifejackets or 1 000 N for 5 min if it is a single load bearing member intended for use in meeting the lifejacket horizontal load test requirement for buoyancy aids.

Table 9 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Requirement[i]
Inadvertent release test (dual-tab closures only)	Standard conditioning	4.7.1.2.3	5	Each sample shall support for 5 min without breaking, and disengagement, or similar condition, a load of at least ½ the minimum tensile strength specified for exposure 1 in the tensile strength test for the standard conditioning using webbing for lifejackets.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] Samples are to be blotted dry to remove surface moisture and are to rest for 30 min at ambient room temperature prior to the strength test.

[c] Immediately following removal from the cold chamber, the samples are to be dropped using different orientations onto a concrete floor five times from a height of 1 800 mm. Each sample is then to be manually operated five times and then examined for signs of cracking. The samples are then to be returned to the cold chamber for 15 min. The samples are then to be individually removed and subjected to the tensile strength test and, depending on the result, also to the strength/slippage test.

[d] Each flexible or moveable tab of polymeric part is to be mechanically operated 5 000 cycles at a rate to 1 cycle/s. The tab is to be completely engaged/disengaged. Also, for hardware which is designed to separate into two parts (i.e. buckles), the parts are to be completely engaged/disengaged. In addition, the samples are to be manually operated 5 times prior to the tensile strength test and strength/slippage test.

[e] The webbing which is used for the applicable tests in 4.7.1.2.1 is to be soaked in fresh water for 2 min prior to the strength/slippage test.

[f] Strength values are for the fixed-straight-length body strap method. The values are to be doubled for the closed-loop assembly method.

[g] Exposure tests to be based on typical fuels used in the intended area of application.

[h] ECE non phosphate detergent.

[i] For compliance see 4.1.3.

4.7.1.2.2.2 Loop assembly method

For the loop assembly method, each assembly shall be closed to form a loop. Each assembly loop shall be supported vertically over a cylinder, with a second cylinder providing means for load application, illustrated in Figure 3. The body strap shall be marked at the sample to allow for measurement of the slippage after the test. Twice the applicable load specified for the fixed straight-length method shall be applied.

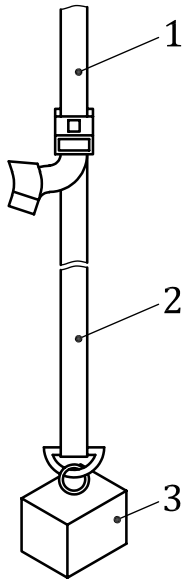
4.7.1.2.2.3 Fixed straight-length method

For the fixed straight-length method, connect a static load to one length of the body strap illustrated in Figure 3. For this test method, one length of the body strap shall be attached to a hoist and the other end to a weight. The body strap shall be marked at the sample to allow for measurement of the slippage after the test. The applicable load shall be applied through the bottom piece of the body strap.

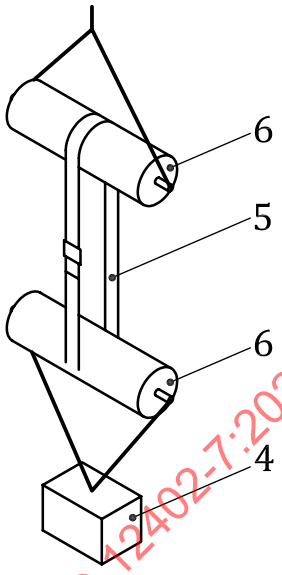
4.7.1.2.3 Inadvertent release test (dual-tab closure)

With one tab depressed, the samples shall comply with the requirement specified in Table 9.

The webbing and test method shall be as described for the fixed straight-length body strap test method specified in 4.7.1.2.2.3, except that one tab shall be depressed. A pre-load of (2,3 ± 0,5) kg shall be applied to each closure so that when the release tab is depressed it does not slip back into the locked position. The remaining load shall then be applied.



a) Fixed straight-length method



b) Loop assembly method

Key

1 600 mm length body strap rigged to hoist and hardware
2 600 mm length body strap rigged to weight No. 1
3 weight No. 1 (for fixed straight-length test)
4 weight No. 2 (for closed loop test, twice weight No. 1)
5 1 200 mm length body strap rigged to hardware
6 cylinder of 124 mm diameter

Figure 3 — Strength/slippage test methods

4.7.2 Lacing closures and adjusters

4.7.2.1 General

Structural closures and adjusters for lacing used in a primary or secondary closure or adjustment system shall comply with Table 10 when subjected to the tests specified in this table.

4.7.2.2 Performance

4.7.2.2.1 Tensile strength

Each assembly shall consist of the sample with two lengths of 150 mm of lacing attached as they are for use. For hardware that depends on friction for adjustment of the lacing, any adjustment tab shall be depressed with a force of 5 N to secure the lacing prior to testing.

The tester shall be a constant-rate-of-extension (CRE) tensile test machine as described in the specification for tensile testing machines for textiles, with a rate of extension of (300 ± 10) mm/min. The front and back jaws of the clamps shall be at least as wide as the lacing being used on the samples. The gauge length shall be $\left(50^{+5}_{-0}\right)$ mm longer than the width of the sample being tested.

The sample shall be mounted in the tensile machine by securing each length of lacing in opposite clamps so that the lacing grip area of the sample is centred between the clamps both vertically and horizontally. Only the ends of the lacing which result in the binding of the lacing to the hardware when under load shall be secured to the clamps. The clamps shall be separated until breakage, disengagement, lacing

slippage in excess of 75 mm or a similar condition occurs. The maximum value (breaking load) to cause failure shall be recorded.

4.7.2.2.2 Strength/slippage

4.7.2.2.2.1 General

Each assembly shall consist of the sample with 1 200 mm of lacing attached as for use. For hardware that depends on friction for adjustment of the lacing, any adjustment tab shall be depressed with a force of 5 N to secure the lacing prior to testing. Also, it shall be possible to conduct this test in accordance with either the fixed straight-length method or the loop assembly method. This test shall be conducted with each lacing for which the hardware is intended.

4.7.2.2.2.2 Loop assembly method

For the loop assembly method, each assembly shall be closed to form a loop. Each assembly loop shall be supported vertically over a cylinder, with a second cylinder providing the means for load application, similar to the method illustrated in Figure 3. The lacing shall be marked at the sample to allow for measurement of the slippage after the test. Twice the applicable load specified in Table 10 shall be applied.

4.7.2.2.2.3 Fixed straight-length method

For the fixed straight-length method, connect a static load to fixed straight 600 mm lengths of lacing on each side of the sample, similar to the method illustrated in Figure 3. For this test method, one length of the lacing shall be attached to a hoist and the other end shall be attached to a weight in accordance with Table 10. The lacing shall be marked at the sample to allow for measurement of the slippage after the test. The applicable load specified in Table 10 shall be applied through the bottom piece of lacing.

4.7.2.2.3 Tab disengagement test

Each assembly shall consist of the sample with two lengths of 600 mm of lacing attached as they are for use. For hardware that depends on friction for adjustment of the lacing, any adjustment tab shall be depressed with a force of 5 N to secure the lacing prior to testing.

One of the lacing ends that results in the binding of the lacing to the hardware shall be secured in a rigid fixture. The other lacing end that results in the binding of the lacing to the hardware shall be attached to a 2,25 kg deadweight. The deadweight shall be suspended from the lacing and then raised 300 mm from the suspended position. The deadweight shall then be released so a shock load is applied to the sample.

Table 10 — Lacing closures and adjusters

Property	Exposure	Test method	Number of samples[a]	Requirement[h]
Tensile strength	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[b,f] 3) 70 h immersion in 0,5 % detergent[g] according to ISO 6330:2012 4) (70 ± 2) °C for 7 days[b] 5) (−30 ± 2) °C for 24 h[c] 6) 720 h of salt spray according to 4.1.5.2 7) Fatigue[d] 8) Accelerated weathering according to 4.1.6.4	4.7.2.2.1	5 for each separate exposure	Following exposure 1, each sample shall have a minimum breaking strength of 1 000 N. Also, for exposures 2 to 8, the tensile strength shall be at least 600 N. Results shall be given as average of the five samples.
Strength/ slippage	1) Standard conditioning 2) 2 min water soak[e]	4.7.2.2.2	5 for each separate exposure	For exposures 1 and 2, each sample shall have a breaking strength of no less than 1 000 N. Following exposures 2 to 8 the tensile strength shall be no less than 600 N. Results shall be given as average of the five samples. For exposures 1 and 2, each sample shall support without breaking, distorting, or slipping more than 25 mm a weight of 1 000 N for 10 min using the fixed-straight-length body strap method. The load is to be doubled for the closed-loop assembly method.

Table 10 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Requirement[h]
Tab disengagement test	Standard conditioning	4.7.2.2.3	5	A moveable tab shall remain engaged and operable when subjected to a shock load of (6,8 ± 0,2) J.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] Samples are to be blotted dry to remove surface moisture and are to rest for 30 min at ambient room temperature prior to the strength test.

[c] Immediately following removal from the cold chamber, the samples are to be dropped using different orientations onto a concrete floor five times from a height of 1 800 mm. Each sample is then to be manually operated five times and then examined for signs of cracking. The samples are then to be returned to the cold chamber for 15 min. The samples are then to be individually removed and subjected to the tensile strength test and strength/slippage test.

[d] Each flexible or moveable tab of polymeric part is to be mechanically operated 5 000 cycles at a rate to 1 cycle/s. The tab is to be completely engaged/disengaged. Also, for hardware which is designed to separate into two parts (i.e. buckles), the parts are to be completely engaged/disengaged. In addition, the samples are to be manually operated 5 times prior to the tensile strength test and strength/slippage test.

[e] The lacing which is used for the applicable tests in 4.7.1.2.1 is to be soaked in fresh water for 2 min prior to the strength/slippage test.

[f] Exposure tests to be based on typical fuels used in the intended area of application.

[g] ECE non phosphate detergent.

[h] For compliance see 4.1.3

4.7.3 Multi-eyelet guides

4.7.3.1 Construction

A multi-eyelet guide for use with lacing shall comply with the requirement specified in Table 11 when subjected to the tests specified in this table.

4.7.3.2 Performance

4.7.3.2.1 Tensile strength

Each sample shall be cut into test specimens 25 mm wide with one lacing loop centred. Each sample shall be independently mounted in a constant-rate-of-traverse (CRT) tension machine. The flat side of the sample shall be clamped in one jaw and lacing shall be passed through the loop of the sample. Each end of the lacing shall be clamped in the other jaw of the tension machine. The initial jaw separation shall be 100 mm to 150 mm. The jaws shall be separated at a rate of 75 mm/min and the load in N at rupture shall be recorded.

4.7.3.2.2 Cold flexibility test

Immediately upon removal from the cold chamber, each sample specimen shall independently be bent both lengthways and widthways around a 25 mm mandrel until each end touches. The mandrel shall be in the cold chamber with the samples during the exposure.

Table 11 — Multi-eyelet guides

Property	Exposure	Test method	Number of samples[a]	Requirement[b]
Tensile strength	See Table 10	4.7.3.2.1	5 for each exposure	The tensile strength shall not be less than 450 N. Results shall be given as average of the five samples
Cold flexibility	(–30 ±2) °C for 24 h	4.7.3.2.2	5	Each sample shall not break or be permanently distorted.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For compliance see 4.1.3.

4.8 Foam flotation material

4.8.1 General

The properties of foam flotation material shall be investigated in accordance with Table 12 and 4.8.2 and shall comply with the requirement specified therein.

Except where otherwise noted, samples of foam flotation material shall measure at least 300 mm by 300 mm by the thickness of the material being investigated. When a material is 16 mm thick or less, the material shall be stacked to the number of layers that provides samples closest to 25 mm in thickness. The condition of the material shall be representative of that intended for the end-product (for example, with or without skin).

For the purposes of these requirements, skin is a dense outer layer of the foam flotation material. Tests shall be provided in three batches, see Table 12 for precise number of samples.

Table 12 — Foam flotation material

Property	Test method	Number of samples	Requirement[a,h]
Density	4.8.2.1	6	Baseline test.
Specific buoyancy	4.8.2.2	6	Baseline test.
Compression[c]	4.8.2.4 or 4.8.2.5[g]	3[b]	The loss of buoyancy shall not be greater than 10 %. Results shall be given as average of the three samples
Thermal stability[c]	4.8.2.3 or 4.8.2.5[g]	3[c]	The maximum loss of volume in any sample shall not exceed 5 % and there shall be no sign of damage such as shrinking, cracking, swelling, dissolution or change of mechanical qualities, when compared with unconditioned specimens[g].
Buoyancy retention factors, alternative to compression and thermal stability[c,g]: V-factor (for wearable devices)	4.8.2.5	6[b]	94 V for material used to make up at least 85 % of the required buoyancy in a lifejacket meeting ISO 12402-2:2020 and ISO 12402-3:2020. 85 V for material used to make up at least 85 % of the required buoyancy in a lifejacket meeting ISO 12402-4:2020, ISO 12402-5:2020 and ISO 12402-6:2020. 80 V for material making up no more than 15 % of the required buoyancy in any lifejacket.
Tensile strength	4.8.2.6	6[d]	The tensile strength shall be not less than 140 N/mm^2 for foam which is a structural part of the device, i.e. not retained by a cover fabric. Results shall be given as average of the six samples.

Table 12 *(continued)*

Property	Test method	Number of samples	Requirement[a,h]
Oil resistance	4.8.2.7	3[d]	There shall be no visible volume change, softening, nor deterioration of a material when compared with unconditioned specimens. The tensile strength shall be not less than 75 % of the value determined for the unconditioned specimens. Results shall be given as average of the three samples.
Cold flexibility	4.8.2.8	3[d]	There shall be no cracking when examined under a magnification of 5 times.
Compression deflection	4.8.2.9	3[e]	The force required to deflect the material to 75 % of its original thickness shall be at least 7 kPa.
Thickness	4.8.2.10	4[h]	Baseline test.

[a] The use of foam buoyant material is dependent on (and not limited to) the thickness, buoyancy retention factor, the type of personal flotation device for which it is intended, and how it is enclosed in the personal flotation device.

[b] The samples are to be the same samples used in the specific buoyancy measurements.

[c] This property shall be investigated for each nominal thickness in which the foam flotation material is produced; except that for material produced in thicknesses greater than 25 mm, a plot of property values versus thickness based upon at least three thicknesses (thinnest, midrange, and thickest) of 25 mm and greater are used to obtain values for intermediate thickness.

[d] Samples from one or more lots.

[e] One sample from each lot.

[f] Two samples from batch 1 and one sample each from batches 2 and 3.

[g] When the alternative tests in 4.8.2.5 are used, the resulting retention factors shall be used to compensate for the projected loss of buoyancy as specified in 5.3.3.2 of ISO 12402-2:2020, ISO 12402-3:2020 and ISO 12402-4:2020 and as specified in 5.3.4.3 of ISO 12402-5:2020, respectively.

[h] For compliance see 4.1.3.

4.8.2 Performance

4.8.2.1 Density after water absorption

The mass of each individual sample shall be determined by using an analytical balance with an accuracy of ±0,5 g. The samples shall then be immersed to a depth of 50 mm in fresh water at room temperature for 24 h. The initial volume of each sample shall be determined immediately after the water soak specified by

a) measuring and recording the initial water level, W_i, in an inclined manometer tube to the nearest 1,0 mm;

b) submerging the foam in a rigid container (that is connected to the manometer) filled with fresh water; and

c) measuring and recording the final water level, W_f, to the nearest millimetre.

The volume, V, of an individual sample of foam flotation material, in mm^3, shall then be calculated by multiplying the difference between the water levels W_f and W_i by the cross-sectional area, A, of the rigid container according to Formula (2):

$$V = (W_f - W_i) \times A \tag{2}$$

where

W_f is the final water level of manometer container, in mm;

W_i is the initial water level of manometer container, in mm;

A is the horizontal cross-sectional area of the container (i.e., $L \times W$), in mm^2.

The density, D, of the individual sample, in kg/m^3, shall then be determined by the following Formula (3):

$$D = \frac{m}{V} \tag{3}$$

where

m is the mass of an individual sample, in kg;

V is the volume of an individual sample, in m^3.

An alternative method to find the density may be used, if it can be documented that the method used is equivalent or more accurate than the method specified in this standard.

4.8.2.2 Specific buoyancy

The corrected initial buoyancy, B_{CI}, in N, of each sample shall be determined, after 24 h of water immersion to a depth of 50 mm of fresh water at room temperature, by

a) weighing the sample to the nearest 1,0 g while completely submerged underwater;

b) reading the individual buoyancy to the nearest 1,0 g directly from the digital readout; and

c) correcting the results to an atmospheric pressure of 760 mm Hg and a water temperature of 20 °C according to Formula (4):

$$B_{CI} = B_I \times \frac{P_I}{101{,}3} \times \frac{293{,}15}{T_I + 273{,}15} \tag{4}$$

where

B_I is the initial measured buoyancy, in N;

P_I is the initial atmospheric pressure, in kPa;

T_I is the initial temperature, in °C.

The initial specific buoyancy value, B_{SI}, in N/mm^3, of each sample shall be individually computed in accordance with Formula (5):

$$B_{SI} = \frac{B_{CI}}{V} \tag{5}$$

where

B_{CI} is the corrected initial buoyancy, in N, determined in accordance with Formula (4);

V is the volume of an individual sample, in mm^3, determined in accordance with 4.8.2.1.

4.8.2.3 Thermal stability of buoyancy material

Three test specimens of dimensions (200 ± 2) mm by (200 ± 2) mm of a thickness of at least 20 mm shall be conditioned initially in air at (23 ± 2) °C and (50 ± 5) % relative humidity for at least 24 h before carrying out the test. If the buoyancy material is of a granular form, or consists of sheets thinner than

20 mm, then either a number of layers shall be used to achieve a minimum total thickness of 20 mm, or a minimum volume of material of 0,1 l shall be tested, as appropriate.

Each specimen shall then be weighed in air, and undergo measurements to determine their volume. If the volume is measured by displacement of water, the specimens shall be conditioned in air at (23 ± 2) °C and a relative humidity of (50 ± 5) % for (24,0 ± 0,5) h.

They shall then be placed on a flat surface in an oven maintained at an even temperature of (60 ± 1) °C with air circulating at the rate of 3 to 10 changes/h, for a period of (7,0 ± 0,1) h. Only test specimens from the same type material shall be conditioned in one oven at a time.

Following removal from the oven, specimens shall be laid on a flat surface for (17,0 ± 0,1) h at (23 ± 2) °C and (50 ± 5) % relative humidity.

They shall then be exposed in a similar container to an even temperature of (–30 ± 1) °C for a period of (7,0 ± 0,1) h, then removed and laid on the flat surface for (17,0 ± 0,1) h at room temperature as before.

This cycle of exposure to alternating high and low temperatures shall be repeated until the samples have been exposed to each temperature for ten periods. The measurements shall then be repeated, and the percentage volume change calculated.

4.8.2.4 Test method for the compressibility of inherently buoyant material

4.8.2.4.1 Examine three specimens of each sample of foam of dimensions (100 ± 2) mm by (100 ± 2) mm and of a thickness of at least 20 mm. If the material consists of granules, then fill three cloth sacks with the granules to the same filling density as the lifejacket or buoyancy aid. Fit them into a metal frame of dimensions 100 mm × 100 mm and a height equivalent to the thickness of the inherently buoyant material. Prior to the test, they shall have been stored at (23 ± 2) °C and a relative humidity of (50 ± 5) % for at least 24 h, in which conditions they shall be tested.

4.8.2.4.2 Each specimen shall be placed in fresh water under a flat metal plate at least 20 % larger than the specimen size and then compressed at a speed of 200 mm/min until a load of 50 kPa has been reached. This lower position shall be set for further compressions. The specimen shall then be completely decompressed, and the cycle of compression repeated a further four times, using the lower set point as the limit of compression.

4.8.2.4.3 The specimen shall then be kept under the metal plate such that it is only just weighted by the plate to remain under water. The load required to achieve this shall be recorded as the original buoyancy (note that it might be necessary to use a different load cell from that required by 4.8.2.4.2).

4.8.2.4.4 The specimen shall then be dried for 7 days in air at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %. The compression cycle at 4.8.2.4.2 shall then be repeated without water, and for a total of 500 times. If deformation occurs, then the upper set point may need to be reset in order to keep the decompression time equal during the whole period.

4.8.2.4.5 The specimen shall then be returned to the atmosphere at 4.8.2.4.4 for at least three days, and the buoyancy measurement at 4.8.2.4.2 and 4.8.2.4.3 repeated, giving the value B. The loss of buoyancy (as A – B) shall then be expressed as a percentage of the original buoyancy (A).

4.8.2.5 Buoyancy retention factor (V-factor method)

4.8.2.5.1 General

When this test procedure is used, the resulting retention factors shall be used to compensate for the projected loss of buoyancy as specified in ISO 12402-2:2020 to ISO 12402-6:2020.

4.8.2.5.2 Conditioning

The samples shall be subjected to the following sequential conditioning.

a) Initial storage. The samples shall be individually stored on racks for (120 ± 1) h at (23 ± 2) °C.

b) Initial immersion. The samples shall be immersed in fresh water at room temperature for (24 ± 0,5) h with their top surface at a depth of (50 ± 5) mm, followed by measurement of the initial buoyancy of each sample by determining, to the nearest 0,01 N, the force needed to keep the sample at this depth.

c) Heat conditioning. The samples shall be conditioned for 120 h in an air-circulating oven at a temperature of (60 ± 2) °C. A spacing of at least 25 mm shall be maintained between the samples.

d) Cool-down. Immediately after removal from the oven, the samples shall be immersed to a depth of (50 ± 5) mm in fresh water at a temperature of (23 ± 2) °C for (15 ± 1) min.

e) V-factor compression. Immediately after removal from the water, the samples shall be subjected to a load of (120 ± 6) kg as described in f).

f) Compression application. Each individual sample shall be placed on top of a flat, rigid surface that extends at least 25 mm beyond the sample on all sides. The specified load for V-factor testing [see e)] shall be uniformly applied to the top of the sample for (24 ± 0,5) h. The ambient temperature shall be (23 ± 2) °C during the compression application.

NOTE Provided that each individual sample is placed between two flat, rigid surfaces that extend at least 25 mm beyond the sample on all sides, this loading arrangement may be achieved by stacking up to nine layers with the load applied to the top of the stack.

g) Recovery storage. All the samples shall be stored on racks at (23 ± 2) °C for (264 ± 1) h. A spacing of at least 25 mm is to be maintained between the samples.

h) Final immersion. The samples shall then be completely submerged in fresh water at room temperature for (24 ± 1) h with their top surface at a depth of (50 ± 5) mm, followed by measurement of the final buoyancy (B_f) of each sample by determining, to the nearest 0,01 N, the force needed to keep the sample at this depth.

4.8.2.5.3 Calculations

The V-factor for the foam flotation material, as determined from the buoyancy of individual samples subjected to the conditioning and 120 kg compression specified in 4.8.2.5.2, shall be calculated using the Formula (6) and rounding off the value obtained to the nearest whole number:

$$\text{V-factor} = \frac{100}{N} \sum_{i=1}^{N} \frac{B_f}{B_i} \tag{6}$$

where

B_f is the final buoyancy of an individual sample, as determined in accordance with 4.8.2.5.2 h);

B_i is the initial buoyancy of an individual sample, as determined in accordance with 4.8.2.5.2 b);

N is the number of samples subjected to the compression.

The V-factor assigned to a given thickness of a unique formulation of foam flotation material shall be either the value calculated in accordance with Formula (6) or the lowest V-factor calculated for all greater thicknesses of the same formulation, whichever is lower.

4.8.2.6 Tensile strength

Prior to the tensile strength test, the dumbbell-shaped specimens shall be conditioned under standard conditions.

Dumbbell-shaped specimens shall be cut from the samples using Die A as specified in the standard test methods for rubber properties in tension specified in ISO 1926:2009. Specimens from five of the samples shall be cut parallel to each other, and specimens from the other five samples shall be cut parallel to each other and in the direction perpendicular to that in which the specimens from the first five samples were cut. The top and bottom surfaces of the specimens shall be parallel, and the cut surfaces are to be perpendicular to the top surface and free from sharp or ragged edges. If skin is not a condition of acceptance, any surface skin or irregularities that affect the test results shall be removed by light buffing. When the material is more than 10 mm thick, the samples shall be prepared to a thickness of 10 mm or less.

The cross-sectional area, A, of the dumbbell-shaped specimens, in mm^2, shall be calculated according to Formula (7):

$$A = T \times W \tag{7}$$

where

T is the average of three thickness measurements taken on the narrow section of the cut specimen, in mm;

W is the width of the specimen at the narrow section, in mm.

The tensile strength test for the dumbbell-shaped specimens shall be conducted as follows.

Each dumbbell-shaped specimen shall be individually clamped in the jaws of a tension machine and separated at a rate of 50 mm/min. The value at the time of rupture shall be recorded. After the tensile strength test, the average tensile strength of the samples shall comply with the requirement specified in Table 12.

The tensile strength, F, in N/mm^2, for the dumbbell-shaped specimens is calculated according to Formula (8):

$$F = \frac{L}{A} \tag{8}$$

where

L is the load required to rupture the sample, in N;

A is the cross-sectional area of the specimen, in mm^2.

4.8.2.7 Oil resistance

Specimens shall be prepared as specified in 4.8.2.6.

The dumbbell-shaped specimens shall be completely immersed for 70 h in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017 at (20 ± 2) °C. Upon removal, the specimens shall be blotted with filter paper and compared with unconditioned specimens of the same dimensions for evidence of volume change, softening, or deterioration. The specimens shall stand for 30 min at (20 ± 2) °C. The specimens shall then be subjected to the tensile strength test specified in 4.8.2.6. Following this oil resistance and tensile strength test, the specimens shall comply with the requirement specified in Table 12.

4.8.2.8 Cold flexibility

Samples shall be 25 mm × 200 mm by the thickness of the foam flotation material being investigated.

Prior to the test, the samples shall be conditioned for 4 h in air at (–18 ± 1) °C. While at the same temperature, the longest dimension of the sample shall be wrapped 180° around a steel mandrel within 5 s of removal from the freezer. The mandrel shall have a diameter equal to two times the thickness of the foam flotation material under investigation. The mandrel shall be in the cold chamber with the samples during the exposure.

Following this flexibility test, the specimens shall comply with the requirement specified in Table 12.

4.8.2.9 Compression deflection

Each sample shall be compressed to 75 % of its original thickness. The pressure required to compress the sample to this thickness shall be recorded in kPa.

A compression machine capable of gently compressing, without impact, each sample at a rate of 10 mm/min to 50 mm/min shall be used. The thickness of each sample shall be determined using a dial micrometre accurate to 0,01 mm. The compression machine shall utilize a square foot that is at least (110 × 110) mm in size.

Each sample shall be square, measuring (100 ± 3) mm × (100 ± 3) mm. Place the specimen centred in the line of the axial load on the supporting plate of the apparatus. Bring the compression foot into contact with the specimen and determine the thickness when pressure is detected. Compress the specimen by (25 ± 0,5) % of this thickness at the specified rate and take the reading of the load immediately. Calculate the 25 % compression deflection pressure, P_{CD}, in kPa, according to Formula (9):

$$P_{CD} = \frac{F}{A} \tag{9}$$

where

F is the force required to compress the specimen by 25 % of the thickness, in kN;

A is the specimen compression contact surface area, in m^2.

Following this compression deflection test, the specimens shall comply with the requirement specified in Table 12.

4.8.2.10 Thickness

A dial-indicator measuring instrument with a circular presser foot area of 625 mm^2 which exerts a pressure of 28 g shall be used for measuring the thickness of the samples. The indicator shall have a measuring accuracy of ±0,1 mm. Five thickness measurements shall be made on each sample, and the average shall be computed for each sample. The average of the four samples shall then be calculated.

4.8.3 Knitted fabric laminated to foam flotation material

Structural-fabric-laminated foam flotation material, either one sided or two sided, shall comply with the requirement specified in Table 13 or 14 as applicable, when subjected to the tests therein.

The foam provided with fabric-laminated foam flotation material, if required as part of a device's buoyancy, shall comply with the requirements for foam flotation material, except that the material shall be tested in the thickness provided, not stacked to 25 mm. The average of 8 samples shall be at least 220 N.

Table 13 — Fabric tests for knitted fabric laminated foam flotation material having fabric on both sides

Property	Exposure	Test method	Number of samples[a]	Sample size mm	Requirement[e]
Tensile strength	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017[b,c] 3) 70 h immersion in 0,5 % detergent according to ISO 6330:2012[d] 4) Accelerated weathering according to 4.1.6.4	ISO 1421:2016	5 warp and 5 fill for each separate exposure (thinnest material)	4.8.3	Following exposure 1, the tensile strength shall be at least 45 N. Following each separate exposure in items 2 to 4, the tensile strength shall be at least 25 N. Results shall be given as average of the five samples.
Tear strength	Standard conditioning	ISO 4674-1:2016, Method B	5 warp and 5 fill (all thicknesses)	75 × 200	The tear strength shall be at least 25 N. Results shall be given as average of the five samples.
Adhesion to foam	Standard conditioning	ISO 2411:2017	5 warp and 5 fill (greatest thickness)	75 × 200	Following standard conditioning the adhesion of the foam to the fabric shall be at least 7 N/cm for each direction or the foam tears in lieu of peeling. Results shall be given as average of the five samples.
Effect of abrasion on tensile strength	1) Standard conditioning 2) After abrasion resistance (100 000 double rubs)[b,d]	ISO 13934-1:2013	8 warp and 8 fill for each separate exposure (thinnest materials)	45 × 225	The effect of abrasion on tensile strength shall be at least 220 N. Results shall be given as average of the eight samples.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] See Annex B.

[c] Exposure tests to be based on typical fuels used in the intended area of application.

[d] ECE non phosphate detergent.

[e] For compliance see 4.1.3.

Table 14 — Fabric tests for knitted fabric laminated foam flotation material having fabric on one side

Property	Exposure	Test method	Number of samples[a]	Sample size mm	Requirement[e]
Tensile strength	1) Standard conditioning 2) 70 h immersion in fuel B according to ASTM-D-471 or diesel fuel according to EN 590:2013/ Amd 1:2017[c] 3) 70 h immersion in 0,5 % detergent[f] according to ISO 6330:2012[d] 4) Accelerated weathering according to 4.1.6.4	ISO 1421:2016	5 warp and 5 weft for each separate expo-sure (thinnest material)	4.8.3	Following exposure 1, the tensile strength shall be at least 45 N. Following each separate exposure in 2 to 4, the tensile strength shall be at least 25 N. Results shall be given as average of the five samples.
Tear strength	Standard conditioning	ISO 4674-1: 2016, Method B	5 warp and 5 fill (all thicknesses)	75 × 200	The tear strength shall be at least 25 N. Results shall be given as average of the five samples.
Adhesion to foam	Standard conditioning	ISO 2411:2017	5 warp and 5 fill (greatest thicknesses)	75 × 200	Following standard con-ditioning the adhesion of the foam to the fabric shall be at least 7 N/cm for each direction or the foam tears in lieu of peeling. Results shall be given as average of the five samples.
Effect of abrasion on tensile strength	1) Standard conditioning 2) After abrasion resistance (100 000 double rubs)[b]	ISO 13934-1:2013	8 warp and 8 fill for each separate exposure (thinnest materials)	45 × 225	The effect of abrasion on tensile strength shall be at least 220 N. Results shall be given as av-erage of the eight samples.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] See Annex B.

[c] Exposure tests to be based on typical fuels used in the intended area of application.

[d] ECE non phosphate detergent.

[e] For compliance see 4.1.3.

4.9 Inflation chamber materials

4.9.1 General

Woven compartment materials for hybrid and fully inflatable lifejackets shall comply with the requirement specified in Table 15 when subjected to the tests therein.

The samples shall not include selvage and shall not be subject to more than one exposure.

If the material is susceptible to fungal attack and is used as a water resistant membrane, a test shall be carried out as described in Annex A.

4.9.2 Performance

4.9.2.1 Tensile strength test

Each sample specified in Table 15 shall be tested as specified.

The dimension of the front jaws for each clamp shall be 25 mm × 25 mm and shall be rubber padded to prevent slippage. The dimension of the back jaw for each clamp shall be 25 mm parallel to the application of load by 25 mm or more perpendicular to the application of load. The initial jaw separation shall be 75 mm unless specified otherwise. The tensile testing machine shall be operated at a uniform pulling speed of (300 ± 10) mm/min. The load cell range shall be capable of providing the maximum load to break (break strength value shall be within 5 % to 95 % of full range). The samples shall be placed in the tensile testing machine with the long dimension parallel to the application of load. The samples shall be marked with a line 35 mm from the left edge that extends throughout the sample following along a single yarn. The sample shall be placed in the tensile testing machine with the marked line along the left edge of the upper and lower jaws to provide for equal yarn extension. The sample shall extend 10 mm above the top jaw and 10 mm below the bottom jaw.

4.9.2.2 Trapezoid tear strength test

Two samples, measuring 75 mm wide by 150 mm long, shall be used. The warp samples shall be cut with the long dimension perpendicular to the warp yarns and the filling samples shall be cut with the long dimension parallel to the warp yarns. No two warp samples shall contain the same warp yarns and no two samples shall contain the same weft yarns. No sample shall include selvage.

An isosceles trapezoid having an altitude of 75 mm and bases of 25 mm and 100 mm shall be marked on each sample. A cut approximately 10 mm in length shall be made in the centre of and perpendicular to the 25 mm base. The specimen shall be clamped in the tensile testing machine along the nonparallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut and the long trapezoid base shall lie in the folds. Set the nominal gauge length at 25 mm and select the capacity of the tester suitable for the specimens to be tested. The maximum load required to tear the specimen shall be within the rated operating capacity of the tester. For a constant-rate-of-traverse (CRT) machine, this should be considered as the range of 15 % to 85 % of the rated capacity.

Operate the pulling jaw at (300 ± 10) mm/min.

Table 15 — Inflation chamber materials

Property	Exposure	Test method	Number of samples[a]	Sample size[a] mm	Requirement[e]
Tensile strength (woven fabrics only)[c]	1) Standard conditioning 2) Accelerated ageing 168 h at 70 °C 3) After soil burial and fungus resistance (12 weeks exposure), see Annex A 4) Accelerated weathering according to 4.1.6.4[a,b]	ISO 13934-2:2014	5 warp and 5 weft for each exposure	100 × 150	Following exposure 1, the tensile strength shall be at least 930 N in the direction of greater thread count and 800 N in the direction of lesser thread count. Following exposures 2 and 3, the tensile strength shall be at least 840 N in the direction of greater thread count and 720 N in the direction of lesser thread count. Following exposure 4, the tensile strength shall be at least 560 N in the direction of greater thread count and 480 N in the direction of lesser thread count. Results shall be given as average of the five samples.
Trapezoid tear strength (woven fabrics only)[c]	1) Standard conditioning 2) Accelerated ageing 168 h at 70 °C	ISO 9073-4:1997	5 warp and 5 weft for each conditioning	75 × 150	Following exposure 1, the trapezoid tear strength shall be at least 45 N in the warp direction and 36 N in the filling direction. Following exposure 2, the trapezoid tear strength shall be at least 40 N in the warp direction and 30 N in the filling direction. Results shall be given as average of the five samples.
Permeability	1) Standard conditioning 2) Accelerated ageing 168 h at 70 °C	ISO 7229:2015, using CO_2 gas	3 for each exposure	125 × 125	Following exposures 2 to 4, the permeability shall not be greater than 110 % of that determined value following standard conditioning.

Table 15 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Sample size[a] mm	Requirement[e]
	3) After soil burial and fungus resistance (12 weeks exposure), see Annex A; or after *aspergillius niger* fungus resistance in accordance to ISO 846:2019, Method B. 4) (65 ± 1) °C at 95 % relative humidity for 360 h				
Effect of abrasion on tensile strength	1) Standard conditioning 2) After abrasion resistance (100 000 double rubs)	ISO 13934-2:2014	4 warp and 4 weft for each exposure	250 × 50	Except for a material intended for use under a fabric envelope or otherwise protected, the effect of abrasion on tensile strength shall be at least 75 % of that value determined following standard conditioning. Results shall be given as average of the four samples.
Adhesion	1) Standard conditioning 2) After 42 d at 70° C over water	ISO 2411:2017	5	75 × 200	After conditioning 1: 180 N per 50 mm After conditioning 2: 150 N per 50 mm
Flexibility	1) Standard conditioning 2) After 42 d at 70 °C over water	ISO 7854: 1995, Method A	3	(37,5 ± 0,1) × 125	After conditioning 1: No cracking after 9 000 cycles. After conditioning 2: No cracking after 9 000 cycles.

[a] For fully inflated and packed conditions, only exposure 4 weathering is to be conducted for a material not intended to be fully encased within a cover fabric.

[b] When testing several colours, tests shall be conducted for at least the brightest and the darkest colours as well as the brightest and darkest fluorescent colours.

[c] Where an inflation chamber material has previously been tested and passed all the relevant subclauses of 4.9 and Table 15, and only a change in the colour of the textile has occurred, it is only necessary to repeat 4.9.2.1 and 4.9.2.2 as well as 4.3.3.1 and 4.3.3.3 on any additional colours.

[d] See Annex B.

[e] For compliance see 4.1.3.

4.10 Polymeric foam coatings

4.10.1 Construction

Polymeric foam coatings shall comply with the following requirements specified in Table 16 when subjected to the tests therein.

Except for samples used for the adhesion to foam tests, the tests shall be conducted on samples of the coating that have been prepared, by the specified method, in the form of unsupported film in the minimum thickness specified.

The test piece shall be folded at its centre line, with the external sides laid together, and stored for 30 min in a heating chamber at a temperature of (82 ± 2) °C under a load of 50 N per 50 cm^2. After removal from the heating chamber the sample shall be left to cool down for 2 h under standard atmosphere, then unfolded and examined for blocking or surface damage.

For evaluation, the criteria in 4.10.2 shall be used.

4.10.2 Performance

4.10.2.1 Coating adhesion

Coating adhesion shall be tested in accordance with ISO 2411:2017, at 100 mm/min, and shall be not less than 7 N/cm. It shall also be tested when wet, following ageing according to ISO 188:2011. An exposure of (336,0 ± 0,5) h in fresh water at (70,0 ± 1,0) °C, in accordance with ISO 2411:2017, shall be applied at 100 mm/min, and shall not be less than 7 N/cm.

4.10.2.2 Resistance to flex cracking

Resistance to flex cracking shall be tested in accordance with ISO 7854:1995, Method A using 9 000 flex cycles, following which there shall be no visible cracking or deterioration.

4.10.2.3 Elongation at break

Elongation at break shall be tested in accordance with ISO 1421:2016 using the constant-rate-of-extension (CRE) or constant-rate-of-traverse (CRT) methods following conditioning of (24,0 ± 0,5) h immersion in fresh water at room temperature, and shall be not more than 60 %.

4.10.2.4 Cold flexibility

Within 5 s after removal from the cold chamber, each sample, in turn, shall be bent 180° around a 10-mm-diameter steel mandrel that has been conditioned with the samples.

4.10.2.5 Blocking

Resistance to blocking shall be investigated as follows.

a) Laminated foam flotation material having knitted fabric on both sides shall be tested as specified in Table 13 and shall comply with the requirement therein.

b) Laminated foam flotation material having knitted fabric on one side only shall be tested as specified in Table 14 and shall comply with the requirement therein.

c) The foam provided for fabric-laminated foam flotation material shall comply with 4.8, except that the material shall be tested in the thickness provided, not folded to 24,5 mm.

Blocking and surface damage are defined as follows.

a) No blocking: surfaces are free or adhere slightly.

b) Slight blocking: surfaces need to be lightly peeled to separate.

c) Blocking: surfaces separate with difficulty.

d) Surface damage: surfaces show damage under 5× magnification.

For supported film, the temperature at the centre of the mating surface shall be monitored to verify that the required exposure temperature has been reached. The sample shall be held at the temperature for the required duration.

4.10.2.6 Water absorption

Before water treatment the samples shall be weighed out with an automatic balance having an accuracy of at least 0,1 g.

The test samples shall be submerged in water according to ISO 3696:1987, grade 3, with a temperature of (21 ± 2) °C for 24 h. After the treatment, adherent water shall be removed from the samples by simple cleaning with an absorbent cotton cloth. The weighing of the sample shall take place immediately afterwards. The difference in mass shall be reported as a percentage of the original mass.

4.10.2.7 Volatile loss

The samples shall be weighed, using an automatic balance with an accuracy of at least 1 mg, kept for 48 h in a heating chamber at (105 ± 2) °C, cooled down to room temperature for 2 h and weighed again. The difference in mass shall be reported as a percentage of the original mass.

Table 16 — Polymeric foam coatings

Property	Exposure	Test method	Number of samples[a]	Sample size mm[b]	Requirement[f]
Tensile strength and elongation	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) (70 ± 2) °C for 7 d[e]	ASTM D 882-12, Method A	5 for each direction for each exposure, unsupported film	As specified in ASTM D 412-16	For exposures 1 and 3, the tensile strength (for each direction) shall be not less than 8,3 MPa. For exposures 1 and 3, the elongation shall not be less than 320 %. For exposure 2, the tensile strength (for each direction) shall not be less than 5 MPa. Results shall be given as average of the five samples.
Tear strength	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) (70 ± 2) °C for 7 d[e]	ISO 4674-1:2016	5 for each direction for each exposure, unsupported film	As specified in ISO 4674-1:2016	Following exposures 1 and 3, the tear strength shall not be less than 13 N/mm thickness for each direction. For exposure 2, the tear strength shall be no less than 8 N/mm. Results shall be given as average of the five samples.
Cold flexibility	(–30 ± 2) °C for 4 h	4.10.2.4	5, unsupported film	25 × 200 by the sample thickness	There shall be no evidence of cracking or other damage to the samples when examined under 5× magnification.

Table 16 *(continued)*

Property	Exposure	Test method	Number of samples[a]	Sample size mm[b]	Requirement[f]
Blocking resistance	(82 ± 2) °C for 30 min	4.10.2.5	3, supported or unsupported film[d]	200 × 200 or 100 × 100[c]	There shall be no evidence of blocking or surface damage as defined in 4.10.2.5.
Effect of abrasion on tensile strength	Standard conditioning	ISO 5470-2: 2003, Method 1, see also Annex B	5 each direction, unsupported film	230 × 50	The effect of abrasion on tensile strength (for each direction) shall be no less than 25 N. Results shall be given as average of the five samples.
Adhesion to foam	Standard conditioning	ISO 2411: 2017, method of preparation 1	5 each direction unsupported film	75 × 200	Following standard conditioning, the adhesion of the foam to the film shall be at least 7 N/cm, or the foam shall tear in lieu of peeling. Results shall be given as average of the five samples.
Water absorption	(21 ± 2) °C for 24 h	4.10.2.6	3 unsupported film[d]	25 × 75	The water absorption shall not be greater than a 0,5 % increase in mass. Results shall be given as average of the three samples.
Volatile loss	(105 ± 2) °C for 48 h	4.10.2.7	3 unsupported film[d]	300 × 400	The volatile loss shall not be greater than a 8,0 % loss in mass. Results shall be given as average of the three samples.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] minimum of 1 m of unsupported film, and 460 cm^2 of supported film (see footnote c) both the lightest and darkest colours.

[c] The polymeric coating is to be applied to 12,7 mm thick pieces of PVC foam.

[d] Unsupported film size.

[e] Samples shall be cut from conditioned sheets of unsupported film.

[f] For compliance see 4.1.3.

4.11 Inflation systems for hybrid and solely inflatable lifejackets

4.11.1 Construction

4.11.1.1 General

The operation status of the inflation head shall be clearly indicated by green for “ready to use” and red for “not in function”.

An operating inflation head shall withstand a force of 220 N applied to it without any evidence of fracture, leakage of gas from the buoyancy chamber, or other damage.

Automatic inflation systems shall initiate firing in automatic mode within 5 s.

The force required to manually operate an inflation mechanism shall not exceed 67 N, but shall exceed 13 N when tested and when pulled in the direction instructed by the manufacturer. Any exposed edge or projection of the inflation system shall not be so sharp as to damage the material of an inflatable compartment or constitute a risk of injury to persons during intended use.

Inflation systems shall be unidirectional; that is, at working pressures, the construction shall permit the passage of the inflation medium only in the direction that supplies an inflatable compartment, unless intentionally over-ridden.

All automatic inflators shall pierce a test disc (hereafter named as "cap").

4.11.1.2 Materials

A metallic component of an inflation system shall have salt water and salt air corrosion characteristics equal or superior to those of 410 stainless steel or perform its intended function and have no visible pitting or other damage on any surface after 720 h of salt spray testing in accordance with ISO 9227:2017. Combinations of metals shall be galvanically compatible. The following are exceptions to these requirements.

a) An expendable component (for example, a gas cylinder) is not required to be of corrosion-resistant material when the component is provided with a durable zinc coating or an equivalent protection against corrosion.

b) A component is not required to be of corrosion-resistant material when failure of the component does not affect the ability of the device to meet the requirements of this document.

c) An expendable component used as a sacrificial anode meets the intent of the requirement where galvanic compatibility is not provided.

A non-metallic component of an inflation system shall resist the deteriorating effects of exposure to light, water, gasoline, detergent (ECE non phosphate detergent) dry-cleaning solvent, and motor oil as described in Tables 17 to 20.

4.11.1.3 Oral inflation systems

An inflatable lifejacket shall have a simple and rapid method of deflation, which shall also be used for oral inflation. This oral inflation tube shall be free from burrs and shall incorporate an effective non-return valve.

An inflatable lifejacket shall have a minimum air flow through the oral inflation tube of 100 l/min, and the non-return valve shall open initially at an applied air pressure of between 1,0 kPa and 3,0 kPa, when tested according to Table 19.

If an oral inflation tube protrudes from the surface of the device, and the non-return valve either protrudes from the tube when in normal use or the valve can be separated from the tube, it shall not be removable by a force less than 90 N.

The oral inflation tube shall be removed and connected in parallel with a manometer. Air shall be provided under pressure to the end normally used for inflation, and the other end connected to an air flow meter capable of measuring flows of the order of 0,17 m^3/min. The inflation tube shall be mounted vertically. The air supply shall be turned on and the pressure of the supply gradually increased until the oral inflation valve opens, the pressure of which recorded on the manometer shall be taken as the initial opening pressure. The air supply shall then be increased until a reading of (7,0 ± 0,1) kPa is recorded on the water manometer. When steady conditions supervene, the reading on the air flow meter is taken as the flow through the tube.

An oral inflation system shall be provided with a pressure-actuated inlet valve (see the requirement under oral systems in Table 19. The pressure-actuated inlet valve shall not require a pull, push, or other mechanical action to open the inflation valve.

It shall not be possible to lock an oral inflation mechanism in the open or closed position. A friction fit dust cap shall not be used to lock the mechanism open.

A mouthpiece for an oral inflation system shall not contain

a) lead compounds of which the lead content exceeds 0,5 % of the total mass of the contained solids (including pigments, film solids, and driers),

b) compounds of antimony, arsenic, mercury, or selenium of which the metal content individually or in total exceeds 0,06 % by mass of the contained solids (including pigments, film solids, and driers),

c) barium compounds of which the water-soluble barium exceeds 1 % of the total barium.

4.11.1.4 Actuation and re-arming of manual and automatic inflation systems

Re-arming an inflation system shall not require the use of tools, unless the tool is a non-detachable part of the inflation system or is provided with every inflation system re-arm kit.

Devices shall be designed such that only the proper re-arming sequence is possible and only the correct component orientation is achieved for systems in which the correct re-arming of a manual or automatic inflation system is dependent upon the sequence of re-arming actions or the orientation of user-installed components. For example, automatic systems which utilize a water-sensing element whose orientation within the device is critical to the proper functioning of the device shall be designed such that the element is installed in the correct orientation.

The manual portion of a manual inflation system shall be capable of being manually actuated by one deliberate action by the user.

The manual portion of a manual inflation system shall

a) be designed such that the manual system is not reset without first unseating the spent cylinder, or

b) incorporate user-installed indicating tabs or pins for use when re-arming the device that allows the user to indicate that the manual portion of the device has been installed, such tabs or pins shall break away or otherwise be ejected from the device during manual activation.

An automatic inflation system shall not permit installation of a loaded inflation-medium container unless the device is properly reset (i.e., an inflation-medium container discharges during installation when a system has not been reset).

The pull-mechanism portion of a manual inflation system shall be of a highly visible colour as specified under 4.3.3.

4.11.1.5 Means for verification of mechanism operation

A manual or automatic inflation system shall be designed such that the user is capable of testing the system during re-arming to visually verify that all mechanisms are operating using only components which are integral to the device and without discharging a cylinder.

4.11.1.6 Status indicators

Automatic and manual inflation systems shall be provided with status indicators as follows.

a) The inflation system shall incorporate a cylinder seal indicator. The indicator shall be integral to the device or inflation-medium container and reset to an armed or “ready” condition upon correct installation of a full cylinder.

b) Status indication shall provide information to the user as to whether the device is correctly armed. The readiness of the system shall be displayed using single- or multiple-point status indicator(s).

c) Status indicators shall be designed to provide a visual indication of when the system is ready for use.

d) An armed or "ready" condition shall be indicated by the colour green. An unarmed or "not ready" condition shall be indicated by the colour red. The system is only ready for use when all indicators are green.

e) All status indicators shall be grouped or located such that when installed on a device in their intended position, they can be viewed simultaneously and shall be readily visible over the range described in Table 22 for each status configuration.

f) Electronic status indicators shall be provided with a means to test the working condition of the circuitry and the adequacy of the power supply. A device does not have to comply with this requirement if it has a prominent battery service marking, visible within the indicator, confirming an expiration date to the user.

4.11.2 Performance

4.11.2.1 General

Inflation systems shall comply with the requirements specified in Tables 17 to 21 when subjected to the tests therein.

4.11.2.2 Security of protruding oral inflation valve

Following the conditioning at (–10 ± 2) °C for (48 ± 0,5) h, the initial sticking friction between the oral inflation tube and valves, which rely entirely on friction for retention, shall then be broken by rotating the valve within the tube using pliers. Then, a force of (90 ± 1) N shall be applied to the valve in an attempt to extract it from the inflation tube, within 20 s of removal from the conditioning temperature. The security of the valve shall be observed. This test shall then be repeated following conditioning at standard atmosphere.

4.11.2.3 Overpressure relief valve

Overpressure relief valve systems shall comply with the requirements specified in Table 20 when subjected to the tests therein.

4.11.2.4 Use characteristics test of automatic and manual inflation systems

Each automatic or manual inflation system shall meet the requirement in Table 17 and Table 18 as appropriate, when tested.

Test participants according to 4.11.3 shall be employed. A test participant shall not be familiar with the particular device under test, but shall be familiar with lifejackets in general.

For qualification and orientation of test participants for the status indicator test, each test participant shall be given the following written questions to respond to:

a) "Have you ever been boating?"

b) "What is the purpose of a life vest (or life jacket)?"

Test participants who respond negatively to question a) or incorrectly to question b) shall be eliminated and replaced.

Qualifying test participants are to be given a video orientation which covers the following topics:

c) general purpose of an inflatable lifejacket;

d) general information regarding inflation-medium containers;

e) general principle and method of manual inflation;

f) general principle and method of automatic inflation.

For status indicator test sample preparation, samples of the candidate inflation systems shall be mounted on boards or on inflation cells as follows:

g) one sample properly armed;

h) one sample normally fired manually for devices with manual systems;

i) one sample normally fired automatically for devices with automatic systems;

j) samples incorrectly re-armed, excluding replacement with a fired cylinder;

k) samples incorrectly re-armed, including installation of a fired cylinder.

The order of presentation shall be varied for the different test participants.

Table 17 — Automatic inflation systems

Property	Exposure	Test method	Number of samples[a,b]	Requirement[i]
Use characteristics	Standard conditioning	4.11.2.4 and 4.11.3.3	As required by design features	1) For lifejacket use, automatic inflation systems, correct identification regarding system status, including cylinder seal condition, shall be accomplished by at least 96 % of the 25 or more subjects performing the status indicator evaluation. 2) For lifejacket use, automatic inflation systems, proper rearming of the inflation system shall be accomplished by at least 93 % of the 15 or more subjects performing the rearming evaluation.
Automatic operability	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[g]	4.11.4	For exposure 1: 6 plus 2 extra water sensing elements (when expendable) for each sample. For exposure 2: 4 but without water sensing element during exposure.	1) Following exposures 1 to 5, 6 c), 6 d), and 7, the actuation time shall be not more than 5 s following immersion for each of the trials (i.e. half in fresh water, half in salt water). Except for minimal residual vapour, the gas in the cylinders shall be completely discharged after each trial.

Table 17 *(continued)*

Property	Exposure	Test method	Number of samples[a,b]	Requirement[i]
	4) 70 h immersion in 0,5 % detergent[h] according to ISO 6330:2012 5) (70 ± 2)°C for 168 h[d] 6a) (–30 ± 2) °C for 24 h 6b) (–5 ± 2) °C for 24 h[d] 6c) high to low temperature[e] 6d) low to high temperature[f] 7) 720 h of salt spray according to 4.1.5.2		For exposure 3: 4 For exposure 4: 4 but without water sensing element during exposure. For exposure 5: 100 (may be 10 trials on 10 complete samples) For exposures 6 a), 6 b), 6 c), and 6 d): 4 For exposure 7: 4 but without water sensing element during exposure.	2) Starting within 10 s of removal from the cold chamber following Exposure 6 a), samples shall be dropped 3 times onto a concrete surface from a height of (180 ± 5) cm. The samples shall then be subjected to exposure 6 b). Following exposure 6 b), the actuation time shall be not more than 5 s following immersion for each of the six trials (i.e. three in fresh water, three in salt water). 3) Following exposure 7, samples shall have no visible pitting or other damage on any surface.
Discharge	Same as automatic operability exposures 1, 2, 3, 4, 5, 6 b), and 7.	4.11.7	Three of the samples from exposures 1, 2, 4 and 7 from the automatic operability test with new water sensing elements. Three new samples complete with water sensing elements are to be used for exposures 3, 4, 5, 6 a) and 6 b).	For exposures 1 to 5, and 7, the time for actuation following immersion shall be not more than 5 s. In addition, systems shall achieve 100 % of nominal design buoyancy within 10 s following immersion. For exposure 6 b), the time for actuation following immersion shall be not more than 5 s. In addition, systems shall achieve 50 % of nominal design buoyancy within 10 s following immersion.
Hydro-static proof pressure	Standard conditioning	4.11.4	1 complete	The inflation system shall withstand an internal hydrostatic pressure of (10 300 ± 300) kPa gauge without deformation or leakage.
Proof pressure	Standard conditioning	4.11.4	The sample from the hydrostatic proof pressure test.	After the hydrostatic proof pressure test, the inflation system shall not leak when subjected to an air pressure of 14 kPa gauge for 30 s, followed by an air pressure of 275 kPa gauge for 30 s.
Air flow	Standard conditioning	4.11.4	1 complete	The inflation system meets the intent of the requirement when minimum air flow of 4 l/min at an inlet pressure of 275 kPa gauge.

Table 17 *(continued)*

Property	Exposure	Test method	Number of samples[a,b]	Requirement[i]
Vacuum	Standard conditioning	4.11.4	The sample from the air flow test.	The inflation system shall not show a loss of pressure greater than 1,3 mm of water in 1 min or 2,5 mm of water in 1 h when subjected to a vacuum of 300 mm of water applied so as to reduce the seating spring pressure and with atmospheric pressure on the other side.
Humid atmosphere	Conditioning[c] 168 h at (49 ± 2) °C and $\left(96^{+2}_{0}\right)$ % relative humidity	4.11.8	100 complete (may be 2 trials on 50 complete samples)c	95 % of the sample shall not actuate during the exposure and shall operate as intended following the exposure. Those samples that did not actuate during the exposure shall completely pierce the proof cap within 5 s when immersed following the exposure.
System durability	Standard conditioning	4.11.9	1 complete	The inflation system shall operate as intended.
Pull	Standard conditioning	4.11.11	1 complete	The inflation system shall not be damaged.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For polymeric/metallic inflation systems, a minimum of 102 samples of inflator and 366 samples of cylinder and water sensing element (if using only 10 samples for the automatic operability — test exposure 5, and only 50 samples for the humidity test). When using new samples for each of the tests a minimum of 230 samples of inflator and 366 samples of cylinder and water sensing element.

[c] The test samples are to be placed in an uninsulated, water tight enclosure and draped with a fabric prior to being transferred to the ambient condition and are to be removed from the enclosure upon return to the elevated temperature and humidity condition. A coated fabric shall be used, the same as that used for the buoyancy compartment.

[d] The duration specified is for the first trial. Each sample shall be conditioned for an additional 4 h prior to each subsequent trial.

[e] Each sample is to be placed in a circulating air oven maintained at (70 ± 2) °C for 24 h. The samples are then to be placed in a cold chamber at (–30 ± 2) °C for 24 h. The temperature of the cold chamber is then to be raised to (–5 ± 2) °C for 24 h.

[f] Each sample is to be placed in a cold chamber at (–30 ± 2) °C for 24 h. The samples are then to be placed in a circulating air oven maintained at (70 ± 2) °C for 24 h.

[g] Exposure tests to be based on typical fuels used in the intended area of application.

[h] ECE non phosphate detergent.

[i] For compliance see 4.1.3.

Table 18 — Manual inflation systems

Property	Exposure	Test method	Number of samples[a,b]	Requirement[f]
Use characteristics	Standard conditioning	4.11.2.4 and 4.11.3.3	As required by design features	1) For manual inflation systems, correct identification regarding system status, including cylinder seal condition, shall be accomplished by at least 96 % of the 25 or more subjects performing the status indicator evaluation. 2) For manual inflation systems, proper rearming of the inflation system shall be accomplished by at least 93 % of the 15 or more subjects performing the rearming evaluation.
Manual operability	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017[d] 4) 70 h immersion in 0,5 % detergent[e] according to ISO 6330:2012 5) (70 ± 2) °C for 168 h[c] 6) (−30 ± 2) °C for 24 h[c] 7) 720 h of salt spray according to 4.1.5.2	4.11.5	3 for each separate conditioning.	1) Following exposures 1 to 5 and 7, the force applied to the toggle resulting in piercing shall be not less than 13 N and not more than 67 N. The average force of the three samples shall not be less than 22 N. 2) Within 10 s of removal from the cold chamber following exposure 6, samples shall remain operable when dropped three times onto a concrete surface from a height of (180 ± 5) cm. The force applied to the toggle resulting in piercing shall be not less than 13 N and not more than 67 N for each of the trials. The average force of the three samples shall not be less than 22 N. 3) Following exposure 7, samples shall have no visible pitting or other damage on any surface.
Pull cord strength	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	4.11.5	1 for each separate conditioning[g].	The pull cord, its attachment to the tab, and its attachment to the inflator shall withstand a force of 445 N for 3 s without failing or separating from the inflator.
Hydrostatic proof pressure	Standard conditioning	4.11.5	1 complete	The inflation system shall withstand an internal hydrostatic pressure of (10 300 ± 300) kPa without deformation or leakage.

Table 18 *(continued)*

Property	Exposure	Test method	Number of samples[a,b]	Requirement[f]
Proof pressure	Standard conditioning	See requirement	The sample from the hydrostatic proof pressure test.	After the hydrostatic proof pressure test, the inflation system shall be subjected to an air pressure of 14 kPa gauge for 30 s, followed by an air pressure of 275 kPa gauge for 30 s. The inflation system shall not leak.
Air flow	Standard conditioning	See requirement	1 complete	The inflation system shall allow a minimum air flow of 4 l/min at an inlet pressure of 275 kPa gauge.
Vacuum	Standard conditioning	See requirement	The sample from the air flow test.	The inflation system shall be subjected to a vacuum of 300 mm of water applied so as to reduce the seating spring pressure and with atmospheric pressure on the other side. The inflation system shall not show a loss of pressure greater than 1,3 mm of water in 1 min or 2,5 mm of water in 1 h.
System durability	Standard conditioning	4.11.9	1 complete sample	The inflation system shall operate as intended.
Pull	Standard conditioning	4.11.11	1	The inflation system shall not be damaged.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For polymeric/metallic inflation systems, a minimum of 25 samples, and 121 cylinders.

[c] The duration specified is for the first trail. Each sample shall be conditioned for a 4 h prior to each subsequent trail.

[d] Exposure tests to be based on typical fuels used in the intended area of application.

[e] ECE non phosphate detergent.

[f] For compliance see 4.1.3.

[g] Use of operability test samples is an alternative.

Table 19 — Oral inflation systems

Property	Exposure	Test method	Number of samples[a,b]	Requirement[e]
Oral operability	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/Amd 1:2017[c]	4.11.6	3 for each separate conditioning	1) The crack pressure shall not exceed 3 kPa. 2) The air flow shall be not less than 100 l/min at 7 kPa gauge pressure.

Table 19 *(continued)*

Property	Exposure	Test method	Number of samples[a,b]	Requirement[e]
	4) 70 h immersion in 0,5 % detergent[d] according to ISO 6330:2012 5) (70 ± 2)°C for 168 h 6) (–30 ± 2) °C for 24 h 7) 720 h of salt spray according to 4.1.5.2			
Back pressure	Same as oral operability	See requirement	The samples from the operability test	The samples shall not leak when subjected to a back pressure of 0 kPa to 69 kPa. When leakage occurs using samples from the salt spray exposure or detergent exposure, the valve is rinsed from the outside by agitating the sample in fresh water for a period of not more than 15 s to dissolve any imbedded particles, and the test repeated.

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For polymeric/metallic inflation systems, a minimum of 21 samples.

[c] Exposure tests to be based on typical fuels used in the intended area of application.

[d] ECE non phosphate detergent.

[e] For compliance see 4.1.3.

Table 20 — Over-pressure relief valve systems

Property	Exposure	Test method	Number of samples[a,b]	Requirement[e]
Operability	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4 3) 70 h immersion in fuel B according to ASTM D471-16 or diesel fuel according to EN 590:2013/ Amd 1:2017[c]	4.11.10	3 for each separate conditioning	1) The crack pressure shall not exceed 120 % of the rated pressure and shall not be less than 80 % of the rated pressure. 2) The closing pressure shall be not less than 80 % of the measured crack pressure.

Table 20 *(continued)*

Property	Exposure	Test method	Number of samples[a,b]	Requirement[e]
	4) 70 h immersion in 0,5 % detergent[d] according to ISO 6330:2012 5) (70 ± 2) °C for 168 h 6) (–30 ± 2) °C for 24 h 7) 720 h of salt spray according to 4.1.5.2			

[a] Where various colours are tested, as a minimum both the brightest and the darkest colours and the brightest and the darkest fluorescent colours shall be tested.

[b] For polymeric/metallic inflation systems, a minimum of 21 samples.

[c] Exposure tests to be based on typical fuels used in the intended area of application.

[d] ECE non phosphate detergent.

[e] For compliance see 4.1.3.

4.11.3 Performance tests using human subjects

4.11.3.1 General

The principles of the Declaration of Helsinki as amended shall be considered in so far as applicable. Test subjects shall be generally informed of the methods and intent of the tests and should be in suitable health to perform the tests.

4.11.3.2 Type of inflation system and number of test participants (group size)

Manual inflation system: one group of 25

Automatic inflation system: one group of 25

A minimum of five test participants shall be obtained for each subject group from each of the following age groups:

a) 16 years to 25 years;

b) 26 years to 50 years;

c) 51 years and older.

4.11.3.3 Indicator evaluation

For status indicator evaluations, each test participant from the group shall in turn be instructed that a group of at least four inflation systems will be shown, one of which is correctly armed and the others not, and that they will be asked to identify the one that is correctly armed based on the indicators on the device and any information on the instruction card provided by the manufacturer. They shall be given the manufacturer's hang tag, if any, which is provided with the device when sold (or permanently marked or attached), to help them identify the properly armed system. Each test participant shall then be asked to examine the devices and the instructions provided. Up to 10 min shall be permitted for the examination. Upon completion of the examination, the test participant shall state which device they believe is ready for use. Each test participant's response shall be recorded. The test participant shall be asked to observe manual activation of the device.

At least 24 of the 25 participants shall identify the correct sample. If the required number of participants do not identify the correct sample, but at least 16 of the 25 test participants identify the correct sample, each test participant who identifies an incorrect sample shall be told why the sample they identified is visibly incorrect. These test participants shall again review the orientation video and manufacturer's instructions, and shall then be asked the following questions.

a) "What is the significance of green on this device?"

b) "What is the significance of red on this device?"

c) For manually actuated systems, "What is this for?" (While pointing out the manual pull cord).

d) "What is this for?" (While pointing out the inflation-medium container).

The responses shall be recorded. When any response is incorrect, the test participant shall be told the correct response. These test participants shall then be given a second 10 min opportunity to correctly identify the correctly armed system.

For test participant qualification for the serviceability test, and following completion of the status indicator evaluation, each test participant shall be given the following written questions to answer.

a) "Do you consider yourself to have mechanical aptitude?"

b) "Can you change a bag on a vacuum cleaner?"

c) "Do you assemble things such as toys?"

d) "With good instructions, would you be comfortable resetting a life-vest inflation system?"

Test participants who respond negatively to any of the above questions shall not participate in the serviceability test. Test participants who respond correctly to all of the above questions are qualified as participants for serviceability testing.

For re-arming/serviceability evaluation, test participants qualified for serviceability testing shall be informed that they will be asked to re-arm the inflation system they examined, and shall be provided with the incentive to perform the re-arming correctly. They shall also be instructed that they will be given two re-arming kits and that they are free to test one of the kits if they need to do so in order to satisfy themselves that they can perform the re-arming procedure properly. The participants shall be instructed that the re-arming trial is completed when they present what they believe to be a properly re-armed device (which they have not actuated).

Each test participant shall then be given the manufacturer's instructions for each device (written, pictogram, video, etc.), two re-arming kits, and access to the manufacturer's toll-free telephone number when provided. The test participant shall then be instructed to proceed with the re-arming evaluation.

4.11.4 Operability test of automatic inflation systems

4.11.4.1 Each automatic inflation system shall be conditioned as a complete unit (with flanges, valves, water-sensing elements, and similar materials in place) and without an inflation-medium cylinder (a gas cylinder) being fitted. For Table 17, exposures 6 a), 6 b), and the last cold cycle of 6 c), the largest intended inflation-medium cylinder (a gas cylinder), shall be conditioned for at least 1 h prior to the water drop test.

Water-sensing elements need not be exposed to the following conditions:

a) accelerated xenon weathering;

b) 0,5 % detergent (ECE non phosphate detergent) according to ISO 6330:2012;

c) 720 h salt spray.

4.11.4.2 Following the conditionings, each sample shall be fitted with a new inflation-medium cylinder (a gas cylinder) of the largest size specified by the inflation system manufacturer.

A conditioned water sensing element shall be used for each of the trials, with the following exceptions.

a) When the water-sensing element exposed to fuel according to ASTM D471-16, Fuel B or to diesel according to EN 590:2013/Amd 1:2017 does not perform as required, the elements for this trial shall be replaced with new, unconditioned elements and the following specific marking is required on the shipping container:

   ATTENTION — Lifejackets that use this inflator are required to be marked "Replace water-sensing element if exposed to fuel or oil."

b) When the water-sensing element exposed to IRM 902 oil according to ASTM D471-16 does not perform as required, the elements for this trial shall be replaced with new, unconditioned elements and the marking specified in 4.11.4.2 a) applies.

4.11.4.3 The samples shall be tested by dropping into water that is no more than 300 mm deep. Samples from Table 17 exposures 6 c) and 6 d) (high-temperature and low-temperature exposures) shall be tested within 30 s of removal from the exposures.

Half of the samples are tested in fresh water and half in 5 % mass/volume salt water. The water temperature shall be (20 ± 2) °C, except for the cold temperature exposure where it shall be 0^{+2}_{0} °C.

4.11.4.4 The actuation time — the time interval between the sample entering the water and the onset of bubble discharge due to piercing of the inflation-medium cylinder (gas cylinder) — shall be not more than 5 s.

4.11.5 Operability test of manual inflation systems

Each manual inflation system shall be conditioned as a complete unit (with flanges, valves, etc., in place) and without an inflation-medium cylinder (gas cylinder) fitted.

For Table 18, exposure 7, the largest intended inflation-medium cylinder (gas cylinder) shall be conditioned for at least 1 h prior to the in-water drop test. The test shall be conducted three times for each sample for each conditioning, each time using a new inflation-medium cylinder (gas cylinder) of the largest size specified by the inflation system manufacturer.

Samples from Table 18, exposures 5 and 7, shall be tested as specified within 30 s of removal from the exposures.

When the sample uses an expendable or reusable component such as a clip or pin to reduce the likelihood of inadvertent manual actuation, each trial shall be with the use of that component.

The sample shall be attached to a rigid fixture. Using a constant-rate-of-extension (CRE) tensile test machine with readability to 0,45 N, a force shall be applied to the pull cord in the intended direction of operation at a rate of (127 ± 12) mm/min until complete puncturing of the cap of inflation-medium cylinder (gas cylinder) has occurred. The force required to result in puncturing shall be as specified in Table 18.

4.11.6 Operability test of oral systems

Each oral inlet valve shall be conditioned in an unsealed oral tube without an inflatable bladder attached.

Following the conditionings, a gradually increasing air pressure shall be applied to the valve at a rate of 3,5 kPa/min. The pressure at which the valve begins to open (the crack pressure) shall be not more than 3 kPa.

An air pressure of 7 kPa gauge shall then be applied to the valve. The air flow through the system (i.e., valve and tube) shall be not less than 100 l/min.

4.11.7 Discharge test of automatic and manual inflation systems

Each inflator from the operability tests shall be fitted with an inflatable bladder (made of neutrally buoyant material) with an internal volume that holds the inflation medium from the largest size inflation-medium container specified by the manufacturer without full inflation of the bladder. When required, an alternative method to secure the bladder is to use a new bladder flange piece. However, all other parts of the inflatable assembly (i.e., valve) shall be those conditioned and used in the operability tests, except that a water-sensing element shall not be put in place.

Each inflator with bladder shall be evacuated of air under a vacuum of at least 250 mm of water.

The combined in-water weight of the evacuated inflator with bladder, a fully charged inflation-medium container, and, for automatic inflators, an expended water-sensing element (unassembled), shall be measured to the nearest 1,0 g.

The fully charged inflation-medium container shall be dried and weighed to the nearest 0,1 g.

The test sample shall be assembled using the evacuated bladder, the inflator, and the inflation-medium container after they have been dried and, for automatic inflators, with a water-sensing element as described. For exposures 6 b) and 7 in Table 17, and 7 in Table 18 the assembled test sample shall be reconditioned for several hours prior to the test.

For the (70 ± 2) °C temperature exposure, for automatic inflation systems (Table 17, exposure 5), and for manual inflation systems (Table 18, exposure 5), the assembled test sample shall be reconditioned to (70 ± 2) °C for 1 h after assembly and prior to the in-water discharge test. For the (0 ± 2) °C temperature exposure, for automatic inflation systems (Table 17, exposure 6 b)), and for manual inflation systems (Table 18, exposure 7), the assembled test sample shall be reconditioned to (0 ± 2) °C for 1 h after assembly and prior to the in-water discharge test.

These samples shall be tested within 30 s of removal from the exposures.

A dead-weight shall then be attached to the sample in a manner that does not reduce the volume of the inflatable bladder. The in-water weight of the dead-weight, W_i, shall be calculated according to Formula (10):

$$W_i = A - W \tag{10}$$

where

A is the nominal buoyancy weight, in N;

NOTE 1 For exposures 1 to 6, this weight is 100 % of the nominal design buoyancy.

NOTE 2 For exposure 6 b) in Table 17 and exposure 6 in Table 18, this weight is 50 % of the nominal design buoyancy.

W is the combined in-water weight of the evacuated inflator with bladder and a fully charged gas cylinder, in N.

A test tank of fresh water of such depth as to totally submerge the test sample and bladder shall be used. The temperature of the water in the test tank shall be (20 ± 2) °C for exposures 1 to 6 and 8 (Tables 17 and 18), and 0^{+2}_{0} °C for exposure 6 b) in Table 17 and 6 in Table 18.

The atmospheric pressure shall be (760 ± 5) mm Hg, or the in-water weight of the dead-weight shall be corrected accordingly.

The test sample and weight shall then be dropped into the test tank.

The inflation system shall be mounted on an approved 150 N bladder. The bladder and inflation system shall be mounted on a manikin and immersed in at least the following positions:

a) feet first — Vertical 1;

b) head first — Vertical 2;

c) face up — Horizontal 1;

d) face down — Horizontal 2.

The manikin shall be immersed with a speed of 6 cm/s. The system shall trigger 5 s after full immersion.

These tests shall be performed first with a bladder emptied by hand.

Systems using the bladder as an integral functional component shall be tested with the appropriate bladder. The bladder and the inflation system are then a single system.

For automatic inflators or for the evaluation of the automatic system on manual–automatic inflators, the time interval between the sample entering the water and the audible piercing of the inflation-medium container (the actuation time) shall be not more than 5 s. For manual inflators, the lanyard shall be pulled to puncture the inflation-medium container.

For automatic inflators, the time interval between the sample entering the water and the time at which the weight is lifted from the bottom, or when the weight changes direction from a downward movement to an upward movement (the discharge time), shall be not more than 10 s. Completeness of discharge is indicated by the lifting of the weight.

For manual inflators, the time interval between the manual actuation and the time at which the weight is lifted from the bottom, or when the weight changes direction from a downward movement to an upward movement (the discharge time), shall be not more than 5 s. Completeness of discharge is indicated by the lifting of the weight.

If completeness of discharge is not attained within the specified time, then the inflation-medium container shall be removed, dried, and reweighed. If the difference between the pre-weight and this weight is less than the minimum design charge value for the inflation-medium container (indicating that the cylinder was under-charged), then the trial shall be repeated using a new inflation-medium container that is properly fitted and, if necessary, a new water-sensing element.

4.11.8 Humid atmosphere test of automatic inflation systems

An automatic inflation system shall not actuate during the humid atmosphere cycling exposure according to Table 17. Following the exposure, the system shall operate as intended by piercing a proof disc. The proof cap shall be $\left(6{,}0^{+0}_{-0{,}1}\right)$ mm in diameter and nominally 0,40 mm in thickness. The proof cap shall be constructed of a metal in which the finished cap provides the following characteristics.

a) The minimum piercing force (F_{min}), in N, and minimum work to pierce (W_{min}), in J, based on testing of 100 discs from the test lot, with domed side up, using the CO_2 cylinder piercing test procedure in 4.12.2.9.4 and the cap holder in 4.11.8 b) shall be calculated as follows:

$$F_{min} = F - 3\sigma \geq 260 \text{ N} \quad (11)$$

$$W_{min} = W - 3\sigma \geq 0{,}35 \text{ J} \quad (12)$$

where

F is the mean value for the disc, in N;

W is the mean value for the disc, in J;

σ is the standard deviation for the cap value.

b) The standard proof cap shall be inserted into a proof cap holder with the domed side up. The proof cap holder shall have a 0,38 mm deep, 6 mm diameter recess to centre and hold the proof cap over a 3,4 mm diameter pierce-pin cavity. The holder shall be threaded to fit the inflation system under test. The holder shown in Figure 4 meets the intent of the requirement. For cylinder-seal-indicating cylinders that contain the pierce pin, the cylinder head shall be modified to hold the standard proof cap in a similar manner.

c) The appropriate size cap holder with domed-side-up cap shall be screwed into the threaded opening of the inflation system, and hand-tightened.

d) The inflation system shall be actuated by immersing it in fresh water. The test shall be timed to verify that actuation occurs within 5 s.

e) The proof cap shall be removed and the pierced hole compared against the pierce pin for the inflation system. Penetration occurs when the chamfered portion of the pierce pin completely penetrates the proof disc.

4.11.9 System durability test of automatic and manual inflation systems

An automatic or manual inflation system shall be cycled through 100 actuation and re-arming procedures.

Each of the re-arming/actuation trials shall be performed using a new fully charged inflation-medium container. Following the cycling, each system shall operate as intended.

For manually actuated systems, the operation force shall not exceed 90 N after the last cycle.

4.11.10 Operability test of over-pressure relief valves

The valve shall be cycled 10 times from 0 kPa until reaching the crack pressures after standard conditioning.

4.11.11 Pull test of automatic and manual inflation systems, and cylinder-seal-indicating cylinders

With the inflator fixed in accordance with the manufacturer's instructions, and the cylinder installed on the inflator, a load of 1 110 N shall be applied to the distal end of the gas cylinder, parallel to the length of the gas cylinder, for 5 min.

4.11.12 Window material

4.11.12.1 Window material when used as a non-structural component for viewing the inflation system indicator(s) and CO_2 cylinder(s) shall comply with the requirements of Table 21 when subjected to the tests therein.

Table 21 — Window material

Test	Exposure	Test method	Number of samples	Requirement[a]
Tensile breaking strength and elongation	1) Standard conditioning 2) Accelerated weathering according to 4.1.6.4	ISO 13934-2:2014	5 for each exposure ASTM D 412-16, Method A, Dumbbell	Following exposure 1, the tensile strength shall be no less than 60 N. Following exposure 2, the tensile strength shall be no less than 50 N. Following exposure 1, the elongation shall not increase by more than 10 % of the original length. Following exposure 2, the material shall not increase by more than 30 % of the exposure 1 elongation at break.
Cold crack/ flexibility	(–18 ± 1) °C for 1 h	4.11.12.8	10	No more than two samples shall break.
Visual clarity	1) Accelerated weathering according to 4.1.6.4 2) After abrasion resistance, under a 9 N tension and 9 N load and 250 double rubs (see Annex B)	4.11.12.7	1 for each exposure	Following each exposure, the colours red and green shall be correctly distinguishable for each sample.
[a] For compliance see 4.1.3.				

4.11.12.2 Samples shall be subjected to the high-to-low temperature exposure. The material shall be placed in a circulating-air oven maintained at (70 ± 2) °C for 24 h. The samples shall then be placed in a cold chamber at (–30 ± 2) °C for 24 h and then allowed to return to ambient room temperature.

4.11.12.3 Samples shall be subjected to the low-to-high temperature exposure. The material shall be placed in a cold chamber at (–30 ± 2) °C for 24 h. The samples shall then be placed in a circulating-air oven maintained at (70 ± 2) °C for 24 h and then allowed to return to ambient room temperature.

4.11.12.4 For the tensile strength and elongation tests, after the applicable conditioning, each dumbbell sample shall be cut in accordance with ASTM D412-92, method A, dumbbell die A. The elongation shall be measured at the tensile breaking point.

4.11.12.5 Representative inflator indicator(s) shall be readily visible over the range described in Table 22 when viewed through window material that has been abraded. Six test subjects shall be used for the visual clarity tests in Table 21.

Table 22 — Indicator visibility

Parameter	Red indicator	Green indicator
Minimum viewing distance	2 000 mm	2 000 mm

Table 22 *(continued)*

Parameter	Red indicator	Green indicator
Horizontal (side-to-side) viewing range	90° including head-on	90° including head-on
Vertical (top-to-bottom) viewing range	90° including head-on	90° including head-on

4.11.12.6 Samples for abrasion conditioning shall be cut to 230 mm × 50 mm. Each window material sample shall be abraded with 250 double rubs (continuous cycle) under a tension of 9 N and under a load of 9 N in accordance with Method 5304 of FTMS 191A (see Annex B). The tension of the samples shall be maintained throughout conditioning.

4.11.12.7 The six test subjects used to determine visual clarity shall have 20/20 vision or better.

4.11.12.8 The cold crack/flexibility test shall be conducted with the short ends of each of five 50 mm × 150 mm samples laid one atop the other and their edges shall be placed on an underlying 50 mm × 125 mm stiff, paper card (standard index-file card stock). The sample shall be looped naturally without creases or folds and shall be carefully stapled to the card twice with the staples close together and both parallel to and 10 mm from the 50 mm edges. With the arm rotated 180° from the anvil, the impacting device shall be cooled to a temperature of (−18 ± 1) °C before and during the test.

4.12 Gas-filled cylinders

4.12.1 Construction

4.12.1.1 General

The product is a seamless steel cylinder with an approximately spherical closed end and a gradually tapering open end which forms a neck having a length-to-diameter ratio of approximately one. The neck is threaded, and its open end is sealed immediately after the gas filling operation by closing the neck opening with a suitable cap. The cylinder is positively locked (e.g. via threads 1/2-UNF-20-1A, 3/8-24UNF-24 etc. to a device known as an inflator and, on activation; the inflator pin pierces the steel cap. The stored gas is transferred, via passages in the inflator, to entry port(s) of the buoyancy chamber(s) of the lifejacket.

Refillable gas-filled cylinders are not allowed.

4.12.1.1.1 Cylinder body

The cylinder shall be of seamless construction manufactured by deep drawing and forming, or from seamless tube with formed ends. The stresses induced at the test pressure shall be less than the yield point of the material of the cylinder and the cylinder shall show no permanent distortion after the application of the test pressure.

4.12.1.1.2 Cap

The closure shall incorporate a central pierceable area having a minimum diameter of 2,5 mm.

The cap shall be welded to the neck opening after filling and the weld shall be leak free.

The cap may be designed to serve as a pressure-relief device: the relief pressure shall exceed the test pressure, and be less than the burst pressure of the cylinder.

4.12.1.1.3 Gas charge

The mass of the gas charge shall be as stated on the design drawing as defined in 4.12.1.3.1. When the gas is carbon dioxide, the filling density shall not exceed 0,75 kg/l.

4.12.1.1.4 Surface protection

The outer surface shall be protected against corrosion by methods meeting regulatory requirements. The surfaces shall be smooth and free of any defects likely to adversely affect the integrity of the cylinder. Shot blasting or peening of the outer surface is permitted.

4.12.1.2 Materials

4.12.1.2.1 Cylinder body

The cylinder body shall be of low-carbon steel (0,55 % C max.) made by the basic oxygen process or in an electric furnace, fully killed quality with non-ageing properties or austenitic stainless steels to EN 10088-1:2014. Aluminium may not be used as a material of construction of the cylinder body. The chemical composition and mechanical properties' specification shall be stated on the design drawing as defined in 4.12.1.3.1 and shall be suitable for the production processes and for the use intended.

4.12.1.2.2 Cap

The cap material shall be steel and may be carbon steel, low-alloy steel or austenitic stainless steel suitable for the production processes and for the use intended. The material specification of the cap shall be stated on the design drawing as defined in 4.12.1.3.1.

4.12.1.2.3 Gas

The gas to be filled shall be CO_2 to a quality which conforms to the standard for industrial CO_2 in the country of manufacture, and shall have a purity equal to or greater than 99,5 % and a dew point equal to or less than −45 °C. Other gases or gas mixtures may be used, provided that these gases are not flammable or toxic, nor shall they generate compounds formed by interaction with water buoyancy compartment walls and the like that are flammable or toxic. The gas specification shall be stated on the design drawing as defined in 4.12.1.3.1.

4.12.1.3 Cylinder type

4.12.1.3.1 All cylinders shall be fully described in a design drawing containing the following minimum information:

a) cylinder title and identification;

b) an outline of the cylinder;

c) materials of cylinder and cap;

d) the gas and gas specification [national or international standards or manufacturer's standards and specifications (if the latter, a generic description and specification number/identity, CO_2 according to the relevant standard)];

e) principal dimensions including outside diameter, overall length, minimum wall thickness of cylinder and connection details, in mm;

f) diameter and thickness of the cylinder of pierceable area, in mm;

g) cylinder minimum water capacity, in ml;

h) toleranced mass of gas charge, in g;

i) filling density for CO_2 cylinders (maximum gas charge divided by minimum water capacity) or filling pressure at 15 °C for cylinders filled with permanent gases;

j) test pressure, in MPa;

k) minimum burst pressure, in MPa;

l) corrosion protection specification (national or international standards or manufacturer's standards and specifications (if the latter, a generic description and specification/identity));

m) cap maximum piercing force, in N;

n) maximum cap piercing work done, in J;

o) marking.

An example of a design drawing is given in Annex C.

4.12.1.3.2 A cylinder shall be considered a new cylinder type when:

a) it is made by a different process, or a major process change has been made, or it is made in a different facility;

b) a different material specification is used for the cylinder body or cap;

c) the length is increased or decreased by more than 25 % for cylinders made from seamless tube with hot rolled ends, or the water capacity is increased by more than 10 % for deep drawn cylinders;

d) the external diameter has increased or decreased by more than 5 %;

e) the minimum wall thickness has been reduced;

f) the test pressure has increased to an extent that the wall thickness or cap pierceable area thickness is changed to meet the requirements of 4.12.2.1 or 4.12.2.9.

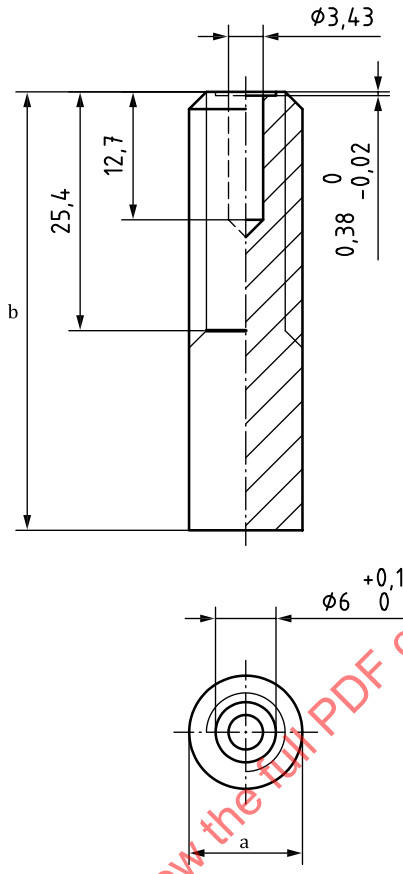
4.12.2 Tests and acceptance criteria

4.12.2.1 Pressure test

All cylinders shall be proof tested at the test pressure as described in 4.12.2.9.1.2 or 4.12.2.9.1.3 and on completion of testing. There shall be no distortion or deformation of the body of the cylinder.

When filled and pressure tested in accordance with 4.12.2.9.1, the upper surface of the piercing area shall not be more than 0,3 mm above or below surface "A" (see Figure 4). There shall be no leakage.

Dimensions in millimetres



a 1/2-20 UNF threaded or 3/8-24 UNF threaded.

b Any suitable length.

Figure 4 — Piercing area detail

4.12.2.2 Burst pressure test (hydrostatic)

Cylinders shall be hydrostatically pressurized to burst as described in 4.12.2.9.2.

No cylinder shall burst below a pressure of 56 MPa or twice the test pressure, whichever is greater.

The burst shall be in the cylindrical portion of the cylinder.

The burst shall be ductile.

There shall be no fragmentation of the body of the cylinder, nor shall the cap (if already welded to the cylinder) become detached.

4.12.2.3 Rupture test (thermal)

The cylinder, complete in all respects, including corrosion protection and marking, shall be heated to bursting as described in 4.12.2.9.3.

The cylinder burst shall be ductile.

There shall be no fragmentation of the body of the cylinder, and the cap shall not become detached.

If the cap also serves as a pressure-relief device, the test shall demonstrate this effect. There shall be no fragmentation.

4.12.2.4 Cap piercing characteristics

Cylinders shall be tested for determination of the piercing characteristics of the cap, as described in 4.12.2.9.4.

For each sample tested, the maximum piercing force, F_{max}, shall be ≤260 N, and the maximum work to pierce, W_{max}, shall be ≤0,35 J.

4.12.2.5 Leakage

All cylinders shall be tested for leakage as described in 4.12.2.9.5.

All cylinders showing evidence of leakage shall be rejected.

All cylinders shall conform to the minimum gross mass marked on the cylinder.

The gross mass of the cylinder shall not exceed the marked minimum gross mass plus 10 % of the nominal gas mass or 2 g, whichever is the greater.

4.12.2.6 Mass or pressure of gas charge

The mass (and pressure for permanent gases) of the gas charge shall be determined as described in 4.12.2.9.6 and shall be as stated in the design drawing defined in 4.12.1.3.1.

4.12.2.7 Cylinder volume and maximum filling

Cylinder volumes and maximum filling shall be determined and checked as described in 4.12.2.9.7. The volume of the cylinder shall equal or exceed the minimum volume shown in the design drawing as defined in 4.12.1.3.1. When the cylinder is filled with a liquefied gas, the filling density shall be equal to or less than the filling density stated on the drawing and shall not exceed 0,75 kg/l for CO_2 or, when any other liquefied gas is used, shall not exceed the filling density corresponding to an internal pressure of 25 MPa at 65 °C.

When the cylinder is filled with a permanent gas, the maximum filling pressure shall be as stated in the design drawing as defined in 4.12.1.3.1.

4.12.2.8 Dimensions and workmanship

4.12.2.8.1 The cylinders shall be inspected for dimensions and workmanship as described in 4.12.2.9.8.

The cylinders shall be free of major defects listed in Table 23. For minor defects listed in Table 23, two defective units per test sample are permitted. The cylinders shall conform to the drawing.

4.12.2.8.2 Corrosion resistance

When tested using a sodium chloride solution (salt spray) and in accordance with ISO 9227:2017 or equivalent national standard for a period not less than 96 h,

a) there shall be no evidence of red rust on any unit following completion of the test, although pinpricks of red rust in the marking indentations (if marking is by indentation) are permitted;

b) the marking shall be legible and complete on all units;

c) if a label is used to carry the marking, the label shall remain securely fixed at the end of the test on all units.