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CAN/CGSB-65.17-2020

Corrigendum No.1, August 2021
Supersedes CAN/CGSB-65.17-2012

Helicopter passenger transportation suit systems

Canadian General Standards Board CGSB

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NATIONAL STANDARD OF CANADA **CAN/CGSB-65.17-2020**

Corrigendum No.1, August 2021
Supersedes CAN/CGSB-65.17-2012

Helicopter passenger transportation suit systems

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE.

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Translation of this National Standard of Canada was conducted by the Government of Canada.

Corrigendum No.1, August 2021
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Preface

This National Standard of Canada CAN/CGSB-65.17-2020 supersedes the 2012 edition.

The standard has been updated to ensure relevance with current performance requirements for a transportation suit system intended for use by helicopter passengers. The standard objective remains focussed on providing a suit system to increase the chance of survivability of the helicopter passenger during the initial hours of immersion in cold water should an emergency situation arise requiring the passenger to suddenly evacuate the helicopter during transportation over water. The main changes in the new edition of CAN/CGSB-65.17-2020 are:

Section 2 Normative references

This section was updated to reflect the most current references available. Main changes are:

- CAN/CGSB-4.2 No. 9.2-M90 replaced by ISO 13934-1:2013 in 5.2.1 and 7.3.1
- CAN/CGSB-4.2 No. 12.1-M90 replaced by ISO 13937-4:2000 in 5.2.2 and 7.3.2
- CAN/CGSB-4.2 No. 32.2-M90 replaced by ISO 13934-1:2013 in 5.1.1 and 7.2.1
- ASTM D3886 replaced by ISO 12947-2
- ASTM D2099 replaced by ISO 811:2018 and/or BS 6F 100
- ASTM D1434 replaced by BS 6F 100 (6.2.4 Gas permeability)

Section 3 Terms and definitions

This section was updated to reflect the most current references available as follows:

- Helicopter Underwater Escape Trainer replaced by underwater egress simulator (UES). Within the marine survival industry, the term HUET is typically reserved for the training program (e.g., Helicopter Underwater Egress Training) and not for the specific device. It was therefore changed to UES.
- Added definitions and reworded requirements to clarify how different components of the suit are to be integrated in testing (definitions for attached components and integral components).
- Suit system redefined to include all integral attached components.
- Added definitions of “immersion donning”, “travel configuration” and “when fitted”.

Section 4 General requirements

- New definition of measuring system.

Section 5 Detailed requirements – Suit system

This section was updated to reflect updated codes and standards. Section changes include seam integrity, exterior fabric integrity, tearing strength, abrasion resistance, water penetration, flame exposure, survivor locator light, and foot protection.

- Retro-reflective material in the suit requirement was increased to 300 cm^2.
- Survivor locator light was redefined to be activated upon contact with water.

- Clarified that test clothing is required to be used during the whole test.
- Added detail to foot protection.
- Added detail to spray shield requirements (adequate ventilation added).

Sections 6 and 7

These sections were updated to reflect updated codes and standards. Changes include:

- New requirement for Welded seams – Raised fabric (6.2.7).
- Added reference to BS EN 14119:2003 standard for evaluation of the action of microfungi (6.8).
- Revised to allow gas cylinders to contain other inert gas, not limited to carbon dioxide.
- Revised flame exposure to include reference to document 14 CFR 25, Appendix F, Part I (6.18).

Annexes

Updated to reference updated codes and standards as per section 2. Changes include the following additions:

- Criteria to pass test for floating life raft boarding (Annex H - 10 subjects shall pass).
- Figure Bohemier perimeter scope (Annex N).
- Alternative method for water ingress (Annex R).
- Description of what is called turbulent water (Annex S).
- Specifications of equipment to test thermal performance (Annex S).

This corrigendum has been published and incorporated in the December 2020 edition of this standard in August 2021.

Corrigendum

- Updated references in section 2 as follows:
  - CAN/CGSB-4.2 No. 32.2-M89 (Extended 1997).
  - CAN/CGSB-4.2 No. 26.1-M88 (Reaffirmed 2001).
  - CAN/CGSB-4.2 No. 9.2-M90 (Reaffirmed 2004).
  - And removal of ISO 1421:2016 —*Rubber or plastics-coated fabrics - Determination of tensile strength and elongation at break*, since it is no longer referenced in the standard.
- In 5.2.2, correction of the requirement to reinstate the 25 N value.
- In 5.22.2.1, correction of the mean thermal insulation value (0.155) to 0.116.
- Various editorial fixes related to the CGSB Style Manual.

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Foreword

The primary objective of this standard is to provide performance requirements for a transportation suit system intended for use by helicopter passengers. A suit system meeting this standard is intended to increase the chance of survivability of the helicopter passenger during the initial hours of immersion in cold water should an emergency situation arise requiring the passenger to suddenly evacuate the helicopter during transportation over water.

This standard applies to suit systems to be worn by helicopter passengers during transportation over water where thermal protection may be required.

In a jurisdiction where it is not regulated, it is strongly recommended that helicopter passengers secure a helicopter passenger transportation suit system that is properly labelled, sized and suitable for use in their particular kind of activity.

WARNING: A suit system meeting this standard that is subsequently altered or that is not maintained in a serviceable condition may no longer perform as originally intended and may no longer meet the performance requirements of this standard thereby affecting its performance.

This standard has been incorporated by reference in several federal and provincial regulations. Where differences exist between the regulations and this standard, the regulatory requirements shall prevail. See Annex A for applicable regulations.

Users of this standard should also be aware that Transport Canada is the approval authority for helicopter passenger transportation suit systems used in Canada. Information on the approval process of helicopter passenger transportation suit systems and Transport Canada requirements may be obtained from Transport Canada Civil Aviation Directorate[1].

[1] For further information contact Transport Canada at Standards Branch, AART, 330 Sparks Street, Transport Canada, Place de Ville, Tower C (AARTC) Ottawa, Ontario K1A 0N5.

Corrigendum No.1, August 2021
Supersedes CAN/CGSB-65.17-2012

Helicopter passenger transportation suit systems

1 Scope

1.1 This standard applies to suit systems to be worn by helicopter passengers during transportation over water where thermal protection may be required.

1.2 The primary function of a suit system meeting this standard is to provide the helicopter passenger protection from the effects of cold water during the initial hours of immersion.

1.3 Helicopter passenger transportation suit systems meeting this standard are tested for flame exposure to ensure they do not sustain flame. The degree of fire protection that the helicopter suit system may provide to the helicopter passenger is not tested.

1.4 Helicopter suit systems meeting this standard are tested as sized, fitted, donned, sealed and used in accordance with the manufacturer's written instructions, which accompany each suit system. Any use of a helicopter suit system that is not in accordance with the manufacturer's instructions is not within the scope of this standard.

1.5 The testing and evaluation of a product against this standard may require the use of materials and/or equipment that could be hazardous. This document does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to its use.

1.6 Units of measurement – Quantities and dimensions used in this standard are given in metric units, mainly SI units, except one for which metric equivalent is stated.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this National Standard of Canada. The referenced documents may be obtained from the sources noted below.

Note: The contact information provided below was valid at the date of publication of this standard.

An undated reference is to the latest edition or revision of the reference or document in question, unless otherwise specified by the authority applying this standard. A dated reference is to the specified revision or edition of the reference or document in question.

2.1 Canadian General Standards Board (CGSB)

CAN/CGSB-3.23 — *Aviation Turbine Fuel (Grades JET A and JET A-1)*

CAN/CGSB-4.2 — *Textile Test Methods*

No. 32.2-M89 (Extended 1997) - Withdrawn standard

No. 26.1-M88 (Reaffirmed 2001) - Withdrawn standard

No. 9.2-M90 (Reaffirmed 2004) - Withdrawn standard

No. 26.1-M88 (Reaffirmed 2001) - Withdrawn standard

2.1.1 Contact information

The above may be obtained from the Canadian General Standards Board, Sales Centre, Ottawa ON Canada K1A 0S5. Telephone: 1-800-665-2472. E-mail: ncr.cgsb-ongc@tpsgc-pwgsc.gc.ca. Web site: www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html, or from the Government of Canada Publications at https://publications.gc.ca/site/eng/search/search.html.

2.2 International Organization for Standardization (ISO)

ISO 811:2018 — *Textiles — Determination of Resistance to Water Penetration – Hydrostatic Pressure Test*

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

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

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

ISO 13937-4:2000 —*Textiles — Tear properties of fabrics – Part 4: Determination of tear force of tongue-shaped test specimens (Double tear test)*

ISO 15027-3 — *Immersion suits — Part 3: Test methods*

2.2.1 Contact information

The above may be obtained from the International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, Tel.: +41 22 749 01 11, E-mail: central@iso.org, http://www.iso.org/iso/home.htm.

2.3 British Standards Institute

BS 6F 100 — *Procedure for inspection and testing of textiles for aerospace purposes*

BS 2F 142:1999 — *Hydrolysis resistant, thermoplastic polyether polyurethane elastomer coated nylon fabric for aerospace purposes* (confirmed May 2018)

BS EN 14119:2003 — *Testing of textiles. Evaluation of the action of microfungi*

2.3.1 Contact information

The above may be obtained from the British Standards. Telephone: 514-940-1778 or 1-800-862-6752. Fax: +1 416-620-9911; Web site: https://www.bsigroup.com/.

2.4 ASTM International

ASTM D1655 — *Standard Specification for Aviation Turbine Fuels*

ASTM D2061 — *Standard Test Methods for Strength Tests for Zippers*

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

ASTM D5587 — *Standard Test Method for Tearing Strength of Fabrics by Trapezoid Procedure*

2.4.1 Contact information

The above may obtained from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, U.S.A., telephone: 610-832-9585, fax: 610-832-9555, Web site: www.astm.org. or from IHS Markit, 200-1331 MacLeod Trail SE, Calgary, Alberta T2G 0K3, telephone: 613-237-4250 or 1-800-267-8220, fax: 613-237-4251, Web site: www.global.ihs.com.

2.5 SAE International

SAE AS6011 — *Cylinders, Carbon Dioxide Filled, Technical*

2.5.1 Contact information

The above may be obtained from SAE International Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096, U.S.A., telephone: 724-776-4841 (1-877-606-7323), fax: 724-776-0790, Email: customerservice@sae.org, Web site: https://www.sae.org.

2.6 Underwriter's Laboratory (UL)

ANSI/UL1191-2011 — *Standard for Safety for Components for Personal Flotation Devices*

UL 1197-2011 — *Standard for Safety for Immersion Suits*

2.6.1 Contact information

The above can be obtained from Underwriter's Laboratory (UL) Headquarters, 333 Pfingsten Road, Northbrook, IL 60062, U.S.A., telephone: 847-272-8800, customer service: 877-UL-HELPS (877-854-3577), Email: CustomerExperienceCenter@ul.com, Web site: https://www.ul.com/.

2.7 U.S. Department of Defence

MIL-PRF-25369 D(1) — *Cartridge, Inflator, Flotation Gear, (Carbon Dioxide), for the Inflation of Pneumatic Life Preservers*

2.7.1 Contact information

The above may be obtained from Federal Aviation Administration Headquarters, 800 Independence Ave., S.W., Washington D.C. 20591, U.S.A., telephone: 855-368-4200, customer service center: 202-366-4000, or from IHS Markit, 200-1331 MacLeod Trail SE, Calgary, Alberta T2G 0K3, telephone: 613-237-4250 or 1-800-267-8220, fax: 613-237-4251, Web site: www.global.ihs.com.

2.8 U.S. Federal Aviation Regulations (FAR)

Part 25 — *Airworthiness Standards: Transport Category Airplanes*

TSO C13f — *Life Preservers*

2.8.1 Contact information

The above may be obtained from Federal Aviation Administration Headquarters, 800 Independence Ave., S.W., Washington D.C. 20591, U.S.A., telephone: 855-368-4200, customer service center: 202-366-4000, Web site: https://www.faa.gov.

2.9 U.S. General Services Administration

Federal Standards:

191A — *Textile Test Methods*

191/5100.1 — *Strength and Elongation, Breaking of Woven Cloth (Grab Method)*

191/5850 — *Accelerated Aging of Cloth (Oven Method)*

191/5960 — *Adhesion of Cemented Seams*

191/5970 — *Adhesion Coating (Adhesive Method)*

2.9.1 Contact information

The above may be obtained from Techstreet, 3916 Ranchero Dr. Ann Arbor, MI, USA 48108, telephone: 1-800-699-9277, Email: techstreet.service@thomsonreuters.com, Web site: http://www.techstreet.com/ or from the International Commission on Illumination.

2.10 International Commission on Illumination (CIE)

CIE 015:2004 — *Colorimetry*, 3rd edition.

2.10.1 Contact information

The above may be obtained from Techstreet, 3916 Ranchero Dr. Ann Arbor, MI, USA 48108, telephone: 1-800-699-9277, Email: techstreet.service@thomsonreuters.com, Web site: http://www.techstreet.com/ or from the International Commission on Illumination.

2.11 International Marine Organization (IMO)

IMO 83 Chapter III, *Resolution A.658 (16).*

2.11.1 Contact information

The above may be obtained from International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, U.K., telephone: 44 (0)20 7735 7611, fax: 44 (0)20 7587 3210, Email: info@imo.org, Publications: sales@imo.org, Web site: http://www.imo.org/EN/Pages/Default.aspx.

2.12 U.K. Defence Standardization (Dstan)

DEF STAN 91-091 — *Turbine Fuel, Aviation Kerosene Type, Jet A-1 (NATO Code: F-35).*

2.12.1 Contact information

The above may be obtained from UK Defence Standardization, Kentigern House, Room 1138, 65 Brown Street, Glasgow, G2 8EX, Email: enquiries@dstan.mod.uk, telephone: +44 (0) 141 224 2531, IHS Markit, 200-1331 MacLeod Trail SE, Calgary, Alberta T2G 0K3, telephone: 613-237-4250 or 1-800-267-8220, fax: 613-237-4251, Web site: www.global.ihs.com.

2.13 See Annex A for applicable regulations.

3 Terms and definitions

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

3.1
airway freeboard
perpendicular distances from the surface of the water to the mouth.

3.2
athletic shoe
a shoe with a non-slip sole designed for sporting activities or as casual footwear.

Note: It can also go by the name of running shoe, gym shoe, tennis shoe, sneaker or trainer. It does not include shoes with cleats in the soles designed to provide traction in turf.

3.3
attached components
components attached in such a way that they can be seen clearly by the user and are physically accessible and operable. They do not attain a position that either degrades the function of the fittings or reduces the wearer's ability to escape or survive.

3.4
buddy line
a suit system component, whether a length of cord or webbing that can be tied or otherwise fixed to another person's suit, or lifejacket, or to a life raft or other objects, to keep the wearer in the vicinity of that person or object.

3.5
buddy line receiving point
point on the suit system where the buddy line from another suit system can be attached to keep the wearers of both systems in close proximity to each other.

3.6
clo value
unit expressing the relative thermal insulation values of various clothing assemblies. One clo is equal to 0.155 °C• m^2 •W^{-1}.

3.7
cold shock
the physiological response of organisms to sudden cold, especially cold water.

3.8
donning
put on and fasten the suit system according to manufacturer's instructions.

3.9
escape buoyancy
buoyancy of the suit system that is overcome when escaping from an immersed inverted helicopter.

Note: Escape buoyancy includes the inherent buoyancy of the components of the suit system and entrapped air but excludes the inflated buoyancy of an inflatable buoyancy element, when fitted.

3.10
exterior fabrics
principal outer fabrics of the suit system, either in the form of a single or composite fabric, exposed to external environmental elements that may affect their performance.

3.11
flight crew member (CARS)
crew member assigned to act as pilot or flight engineer of a helicopter during flight time.

3.12
flotation buoyancy
the buoyancy available to the wearer from all elements of the suit system, including that of inflatable buoyancy element when fitted, but excluding entrapped air.

3.13
horizontal righting
the action of attaining a face-up position from a face-down position in the water.

3.14
immersed clo
the thermal insulation value measured when a suit system is subjected to the effect of hydrostatic compression.

3.15
immersion donning
complete securing of the suit system (gloves, life jacket, spray shield) and ensure it is water tight for immersion according to manufacturer's instructions.

3.16
inflatable buoyancy element
a suit system component that provides an additional source of buoyancy to the suit system's inherent buoyancy.

3.17
inherent buoyancy
the buoyant force provided by a material that displaces a volume of water larger than its own mass. For a suit, the total inherent buoyancy is the buoyant force provided by the combination of materials that form the integral parts of the suit.

3.18
integral components
the component forms a non-removable part of the suit system, which cannot be detached by the wearer. "Attached" means the component is connected to the suit system but can be removed or the wearer can don the suit system without the component.

3.19
passenger
a person, other than a crew member, who is carried on board of an helicopter.

3.20
retro-reflective material
material that reflects light beams back to their points of origin.

3.21
righting
for the purposes of this standard, it consists of horizontal righting (see 3.13) and vertical righting (see 3.32).

3.22
spray shield
a suit system component, which is a cover of the head and/or face in order to reduce or eliminate the splashing of water onto the airways and suit sealing system.

3.23
stability
the ability of the suit system to maintain the person in a face-up position.

3.24
suit system
the combination of all integral and attached components in a suit design.

3.25
suit system component
a fitting that forms an integral or non-integral attached part of the suit system or is attached to the suit.

3.26
survivor locator light
a light emitting device that is automatically activated upon contact with water.

3.27
test clothing
a standardized ensemble of clothing worn by human participants and the thermal manikin during testing of the suit system according to the current standard. Test clothing is to be worn during all testing procedure unless the manufacturer specifies the clothing to be worn under the suit system.

Note: See also 7.7.

3.28
thermal manikin
a model of a human figure with the surface area and shape similar to a 50th percentile male with a surface area of 1.8 m^2 ± 10%.

Note: See also 7.9.

3.29
travel configuration
may allow the options for helicopter passengers to travel with the suit system partially donned, e.g. head and/or hand protection stowed and/or zipper partially open. Hence the term “travel configuration”.

3.30
underwater egress simulator (UES)
facsimile of a helicopter fuselage that can accommodate at least four occupants and can be lowered such that it can stop on the surface of the water and be lowered beneath the surface of the water. It can be rotated below the surface of the water and the rotation can be stopped in any orientation.

Note: See also 7.8.

3.31
vertical positioning
the action of attaining and maintaining a vertical position in the water.

3.32
vertical righting
the ability of a person to attain a heads-up floating position upon entering the water headfirst.

3.33
when fitted
as used in this standard implies the component in question forms part of the suit system either as an integral part or is attached.

4 General requirements

4.1 Additional suit system components — The suit system may incorporate additional components not covered by this standard as long as all requirements in this standard are met with the components present or attached as designed by the manufacturer. See 7.1.2 for testing. This standard does not test the functionality of these additional components.

4.2 Thermal protection — The suit system shall incorporate thermal protection for the entire body except that the eyes, nose, and mouth may be exposed to the extent necessary to optimize vision and respiration.

4.3 Measuring system — Where a measuring system is required by this standard, it shall have a valid calibration to a recognized national standard.

5 Detailed requirements — Suit system

5.1 Seam integrity

5.1.1 Breaking strength — When tested in accordance with ISO 13934-1:2013, the average breaking strength for each type of seam in the exterior fabric of the suit system shall be 300 N (see 7.2.1).

5.1.2 Water penetration — When tested in accordance with ISO 811:2018 or BS 6F 100, section 3.17- *Air Porosity of Coated Fabrics* with the test run at 27.5 kN/m^2 air pressure, leakage shall be nil over a 5 min period.

5.2 Exterior fabric integrity

5.2.1 Breaking strength — When tested in accordance with ISO 13934-1:2013 Breaking strength / Elongation at Break *Textiles - Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method,* the average breaking strength for the exterior fabric of the suit system shall be 300 N (see 7.3.1).

5.2.2 Tearing strength

Test in accordance with ISO 13937-4:2000, *Textiles - Tear properties of fabrics - Part 4: Determination of tear force of tongue-shaped test specimens (Double tear test)*. The average tearing strength for the exterior fabric of the suit system shall be 25 N (see 7.3.2).

5.2.3 Abrasion resistance — When tested in accordance with ISO 12947-2 using a Martindale abrasion tester with a load of 12 kPa applied to the sample holder and a standard wool worsted abradant, breakdown should not occur before 100,000 rubs.

5.2.4 Water penetration — When tested in accordance with ISO 811:2018 or BS 6F 100; section 3.17- *Air Porosity of Coated Fabrics* with the test run at 27.5 kN/m^2 air pressure, leakage shall be nil over a 5-minute period.

5.3 Flame exposure

5.3.1 When the suit system is also the packaging for the inflatable buoyancy element, the suit materials forming the inflatable buoyancy element packaging shall meet the flammability requirements in 6.18.

5.3.2 When tested in accordance with ISO 15027-3, 3.5, first edition, 2002-03-15 *Flammability test,* the suit system shall not sustain burning or continue melting 6 s after removal from the flame (see 7.4).

5.3.2.1 When tested in accordance with Annex B, the wetted surface area present on the undergarment following flame exposure shall not exceed that recorded before flame exposure by more than 10%.

5.4 Kerosene-type fuel exposure — When tested in accordance with Annex C, the exterior fabric and seams of the suit system shall meet the following requirements:

a. The exterior fabric and each type of seam shall exhibit no cracking or swelling.

b. The average breaking strength for each type of seam in the exterior fabric of the suit system after kerosene exposure shall be 150 N when tested in accordance with CAN/CGSB-4.2 No. 32.2-M89 (Extended 1997).

c. Each type of seam that has an effect on watertight integrity after kerosene exposure shall not exhibit any water penetration under a 1 m head of water for a period of not less than 1 h, when tested in accordance with CAN/CGSB-4.2 No. 26.1-M88 (Reaffirmed 2001), with the exception that only one specimen of each seam type shall be tested instead of three specimens.

d. The average breaking strength for the exterior fabric of the suit system after kerosene exposure shall be 150 N, when tested in accordance with CAN/CGSB-4.2 No. 9.2-M90 (Reaffirmed 2004).

e. Each exterior fabric of the suit system after kerosene exposure shall not exhibit any water penetration under a 1 m head of water for a period of not less than 1 h, when tested in accordance with CAN/CGSB-4.2 No. 26.1-M88 (Reaffirmed 2001), with the exception that only one specimen of each seam type shall be tested instead of three specimens.

5.5 Zippers

5.5.1 Opening and closing force — The opening and closing force of the suit system's primary sealing zipper(s) shall not exceed

a. 40 N in the "as received" condition when tested in accordance with ASTM D2062 (see Annex D, D.5),

b. 60 N following temperature conditioning when tested in accordance with ASTM D2062 (see Annex D, D.5),

c. 175 N following salt spray conditioning when tested in accordance with ASTM D2062 (see Annex D, D.5), and

d. 175 N following kerosene-type fuel conditioning when tested in accordance with ASTM D2062 (see Annex D, D.5).

5.5.2 Crosswise strength — When tested in accordance with ASTM D2061-2007, sections 9-16, the crosswise strength shall not be less than 440 N for each sample for Crosswise Strength Test only. See Annex D, D.7.

5.5.3 Diagonal pull — When tested in accordance with Annex D, D.6, the zipper points for each sample shall not pull free.

5.5.4 Leakage

5.5.4.1 When tested in accordance with Annex D, D.8, water leakage shall not exceed 20 g prior to kerosene-type fuel exposure.

5.5.4.2 When tested in accordance with Annex D, D.8, water leakage shall not exceed 20 g following kerosene-type fuel exposure. There shall be no visible degradation of the samples.

5.6 Corrosion — When tested in accordance with Annex E, each metal part of the suit system shall perform its function as intended without impairment.

5.7 Colour of suit system exterior — The colour of the exposed portions (excluding components such as webbing, zips, boots, wrist cuffs, hand protection, face seals, neck seals and other fittings) of the suit system 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 1 and the luminance factor shall exceed the

corresponding factor in Table 1. For fluorescent colours the chromaticity coordinates and the minimum luminance factor shall comply with Table 2. Measure the colour in accordance with the procedures defined in CIE 015:2004, 3rd edition (see 7.5).

Table 1

Chromaticity coordinates *x* and *y* and luminance factor for yellow, orange and red non-fluorescent colours of suit 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	0.610	0.400	>0.15
	0.470	0.330	
	0.525	0.270	
	0.700	0.300	

Table 2

Chromaticity coordinates *x* and *y* and luminance factor for yellow, yellow-orange, orange, orange-red and red fluorescent colours of suit 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 Orange-Red	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	

5.8 Retro-reflective material

5.8.1 The retro-reflective material used on the suit system shall meet the requirements of IMO 83, Chapter III, Resolution A.658(16), Annex 2.

5.8.2 At least 300 cm^2 of retro-reflective material, excluding that around the forearms, shall be visible above the water line. Of this 300 cm^2 reflective material, at least 100 cm^2 shall be affixed to the hood. Test in accordance with Annex F.

5.8.2.1 In those instances where a suit system component can obscure the retro-reflective material on the suit system, retro-reflective material equal to the area of material obscured shall be affixed to the system component responsible such that at least 300 cm^2 of retro-reflective material continues to be visible above the water line at all times, when tested in accordance with Annex F[2].

5.8.3 At least 25 cm^2 of additional retro-reflective material shall also be located within each circumferential quadrant of the forearm.

5.8.3.1 The retro-reflective material on each forearm need not be continuous.

5.9 Survivor locator light

5.9.1 The suit system shall be equipped with a survivor locator light as an integral component.

5.9.2 The survivor locator light shall be automatically activated upon contact with the water.

5.9.3 If the suit system is not being worn and is being stored or transported on board a helicopter, and any suit components contain a lithium battery, the lithium battery shall meet the appropriate aviation standard.

5.10 Whistle

5.10.1 The suit system shall be equipped with a whistle as an integral component.

5.10.2 The whistle shall comply with ISO 12402-8, 5.2, *Whistles*.

5.10.3 The whistle's stowed location shall be visible and accessible to the wearer as per requirements in 5.20.3 and tested in accordance with Annex P, P.6.

5.11 Buddy line

5.11.1 The suit system shall be equipped with a buddy line.

5.11.2 The buddy line shall provide for quick release from the suit system in the event of entanglement or other emergency.

5.11.2.1 When tested in accordance with Annex G, the quick release shall be operable to either 1500 N or the breaking point of the buddy line.

5.11.2.2 When tested in accordance with Annex P, P.6, the quick release shall function with one hand in accordance with the requirements in 5.20.3.

5.11.3 The suit system shall be fitted with a buddy line receiving point.

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[2] For example, the spray shield may at any point in time reduce the area of retro-reflective material visible on the suit system above the water line, thereby reducing its effectiveness.

5.11.4 When tested in accordance with Annex P, P.6, the buddy line's stowed location and the buddy line receiving point shall be visible and accessible to the wearer.

5.11.5 When tested in accordance with Annex P, P.6, the buddy line shall be positioned to be functional with one hand in accordance with the requirements in 5.20.3.

5.11.6 When tested in accordance with Annex G, the buddy line and the buddy line receiving point shall each withstand a pull of 750 N for 3 min and there shall be no damage to the buddy line or damage that could affect the function of the suit system.

5.11.7 When tested in accordance with Annex G, the buddy line and the buddy line receiving point shall break or part from the suit system when a force in excess of 750 N but less than of 1500 N is applied, and there shall be no damage that could affect the function of the suit system.

5.12 Foot protection

5.12.1 The suit system shall include foot protection features that provide thermal protection, puncture and slip resistance, and do not impede the ability to walk, climb, or meet the performance standard in 5.12.2.

5.12.2 The foot protection shall not inhibit helicopter egress as observed during the egress test required in 5.21.

5.13 Spray shield

5.13.1 The spray shield shall be transparent, having adequate ventilation to maintain safe CO_2 levels and minimize fogging.

5.13.2 The suit system shall be equipped with a spray shield as an integral component.

5.13.2.1 When tested in accordance with Annex N, N.7.3, the spray shield shall allow the wearers to see their surroundings.

5.13.3 When tested in accordance with Annex P, P.6, the spray shield shall be easily deployed and shall be capable of being stowed where it does not impede the wearer's vision or impede rescue actions.

5.13.4 When tested in accordance with Annex I, the carbon dioxide level under the spray shield shall not exceed 5% by volume during the 5-minute test period and the average level shall not exceed 2.5% during each 1-minute interval.

5.14 Inflatable buoyancy element — If the suit system is equipped with an inflatable buoyancy element, it shall meet the requirements of section 6.

5.15 Flotation buoyancy

5.15.1 When tested in accordance with Annex J, the flotation buoyancy of the suit system shall not be less than 156 N.

5.15.1.1 Inherently buoyant materials used in the suit system to achieve the flotation buoyancy shall be unicellular foam that meets ANSI/UL 1191-2011, Sections 23 and 24.

5.16 Escape buoyancy — The escape buoyancy shall not be greater than 175 N, when measured in accordance with Annex K.

5.17 Floating characteristics

5.17.1 Freeboard — When tested in accordance with Annex L, L.5, the freeboard shall be greater than or equal to at least 120 mm.

5.17.2 Stability — When tested in accordance with Annex L, L.6, each subject shall assume a face-up flotation position.

5.17.3 Righting

5.17.3.1 Horizontal righting — Each subject shall be turned to a face-up position by the suit system within 5 s or shall be able to adopt a face-up position from a face-down position within 5 s when tested in accordance with Annex L, L.7.1.

5.17.3.2 Vertical heads-up righting — Each subject shall attain a heads-up floating position within 5 s of entering the water when tested in accordance with Annex L, L.7.2.

5.17.4 Vertical positioning — When tested in accordance with Annex M, each subject shall be able to attain and maintain a vertical position in the water. At least 10 out of the 12 subjects shall pass this test.

5.18 Angle of vision

5.18.1 Angle of vision on land — When tested in accordance with Annex N, each subject's lateral field of vision shall be at least 120° for each position.

5.18.2 Angle of vision in the water — When tested in accordance with Annex N, the angle of vision for each subject in the lateral, vertical and horizontal planes shall be

a. unrestricted through an arc of 120° from left to right, water level to water level in the lateral plane,

b. forward through an arc of 60° and backwards through an arc of 15° in the vertical plane,

c. through an arc of 30° starting at right angles to the body and sweeping down towards the feet, parallel to the water surface in the horizontal plane.

5.19 Mobility

5.19.1 Climbing — When tested in accordance with Annex O, O.2, the average time for each subject to ascend and descend the ladder with the suit system donned shall not exceed the average time to ascend and descend the ladder without the suit system by more than 10%.

5.19.2 Walking — When tested in accordance with Annex O, O.3, the average time for subjects to walk with the suit system donned shall not exceed that without the suit system donned by more than 10%.

5.19.3 Boarding a life raft — When tested in accordance with Annex H, at least 10 out of 12 subjects shall be able to board the life raft unassisted.

5.20 Suit system component donning and use

5.20.1 Hood[3] and seal actions — When tested in accordance with Annex P, P.4, if, pursuant to the manufacturer's instructions, the suit system can be worn in the helicopter without donning the hood and/or without securing all seals, each subject shall don and secure the hood and all seals within 10 s.

[3] Even if the suit system is sealed without donning the hood, e.g. neck seal, helicopter passengers will don it prior to immersion to mitigate the cold shock response.

5.20.2 Critical survival actions

5.20.2.1 When tested in accordance with Annex P, P.5.1.1, where hand protection is worn[4] in the helicopter, each subject shall perform the functions described involving the inflatable buoyancy element (if fitted), the spray shield and any other component requiring rapid activation or deployment within 2 min of entering the water.

5.20.2.2 When tested in accordance with Annex P, P.5.1.2, where the option exists to not wear hand protection[5] in the helicopter as in 5.20.2.1, each subject shall perform the functions described involving the inflatable buoyancy element, if fitted, the spray shield, any other component requiring rapid activation or deployment and hand protection within 2 min of entering the water.

5.20.3 Rescue actions

5.20.3.1 When tested in accordance with Annex P, P.6.1.2, for the instance where hand protection is worn[6] to perform rescue actions, each subject shall perform the functions described involving the spray shield, buddy line and whistle within 2 min.

5.20.3.2 When tested in accordance with Annex P, P.6.1.3, for the instance where hand protection is removed[6] to perform rescue actions and then re-donned, each subject shall perform the functions described involving the spray shield, buddy line, whistle and re-donning the hand protection within 2 min.

5.21 Underwater helicopter egress — When tested in accordance with Annex Q, each subject shall exit the helicopter Underwater Escape Simulator (UES) unassisted and no component shall become fully dislodged or completely deployed.

5.22 Thermal performance in water[7]

5.22.1 Water ingress — Water ingress into the suit system shall be measured in accordance with Annex R. The amount of water that enters the suit system as determined by Annex R shall be used when determining the thermal performance of the suit system in accordance with 5.22.2.

5.22.2 Human subjects and thermal manikin — Two methods of evaluating thermal performance of the suit system are provided.

Note: This standard does not establish the equivalency between the two methods.

5.22.2.1 Thermal manikin — When tested in accordance with Annex S, the mean thermal insulation value provided by the suit system shall be at least 0.116 °C• m^2 •W^{-1} (0.75 immersed clo).

5.22.2.2 Human subjects — When tested in accordance with Annex S.3, the suit system shall provide thermal protection such that the body core temperature (rectal) for each test subject does not drop more than 2 ºC for an entire 6 h immersion.

5.23 Impact of jumping — When tested in accordance with Annex T, the suit system and the suit system components, including the inflatable buoyancy element, if fitted, shall not be damaged or detached.

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[4] Hand protection can either be worn or not worn in the helicopter. In the first instance, hand protection is worn in the helicopter because they are an integral part of the suit system or manufacturer's instructions require it. In the second instance, hand protection is not worn because they are not an integral part of the suit system and the manufacturer's instructions do not require the hand protection to be worn in flight. This is taken into account in testing critical survival actions.

[5] Some manufacturers may require or suggest and/or some helicopter passengers may prefer to don the hand protection after exiting the helicopter.

[6] Hand protection may be designed to allow rescue actions to be performed while wearing them or to allow them to be easily removed to perform rescue actions and then easily re-donned. The tests take account of this.

[7] This standard establishes acceptable thermal protection performance upon the following limits: a decrease in core body temperature of no more than 2 °C at any time during a 6-hour immersion in 0-2 degrees, or 0.75 immersed clo as tested in accordance with this standard.

6 Detailed requirements — Inflatable buoyancy element

6.1 General

6.1.1 If a suit system is equipped with an inflatable buoyancy element, it can be an integrated component or an attached component.

6.1.2 The inflatable buoyancy element shall not be capable of automatic inflation.

6.1.2.1 Each flotation chamber of the inflatable buoyancy element shall be capable of being inflated with at least one mechanical inflation valve and with at least one carbon dioxide gas cylinder or an equivalent inert gas. Inert gas selected shall not pose a risk to the health or safety of individuals when discharged in a closed helicopter without ventilation.

6.2 Coated fabrics

6.2.1 Tensile strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with FTMS 191 A, Method 5100.1, the tensile strength of the coated fabric shall be 36.8 N/mm in the warp direction and 31.5 N/mm in the weft direction (see 7.6.2.1).

6.2.2 Tear strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with ASTM D5587, the tear strength of the coated fabric shall be 1.8 N in the warp direction and 1.4 N in the weft direction (see 7.6.2.2).

6.2.3 Coat adhesion strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with FTMS 191 A, Method 5970, the coat adhesion strength shall be 1.8 N/mm (see 7.6.2.3).

6.2.4 Gas permeability — When tested in accordance with BS 6F 100, 3.17, *Air Porosity of Coated Fabrics* with the test run at 27.5 kN/m^2 pressure, there shall be no leakage over a 5-minute period.

6.2.5 Cemented seams

6.2.5.1 Sealing — Cemented seams, when used, shall be sealed with a seam tape that meets the requirements in 6.4 of this document.

6.2.5.2 Shear strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with FTMS 191 A, Method 5100.1 (see 7.6.3.1), the shear strength of the cemented seam shall be at least 30.7 N/mm at 24 ± 2 °C and 7 N/mm at 60 ± 2 °C.

6.2.5.3 Peel strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with FTMS 191 A, Method 5960, the peel strength of the cemented seam shall be at least 1.8 N/mm (see 7.6.3.2).

6.2.6 Heat-sealed seams

6.2.6.1 Sealing — Seam tape, if used, should be in accordance with the requirements in 6.3 of this document.

6.2.6.2 Shear strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1) and when tested in accordance with FTMS 191 A, Method 5100.1 (see 7.6.4.1), the shear strength of the heat-sealed seam shall be at least 7.9 N/mm at 21 ± 2 °C and 5.3 N/mm at 60 ± 2 °C (see 7.6.4.1).

6.2.7 Welded seams – Raised fabric

6.2.7.1 Sealing — Seam tape, if used, in welded seams should be in accordance with 6.3 of this document.

6.2.7.2 Weld strength after aging — After aging in accordance with FTMS 191 A, Method 5850 (see 7.6.1), and when tested in accordance with Test Weld Strength for Raised Fabric - Welded Seams BS 2F 142:1999, Annex A, the strength of welded seams shall be at least 320 N.

6.3 Seam tape

6.3.1 Tensile strength — When tested in accordance with FTMS 191 A, Method 5100.1, the tensile strength of the fabric used for the tape shall be at least 8.8 N/mm in the weft and warp directions (see 7.6.5.1).

6.4 Webbing

6.4.1 Tensile strength — When tested in accordance with FTMS 191 A, Method 5100.1, the tensile strength of the webbing shall be at least 1023 N (see 7.6.6.1).

6.5 Thread

6.5.1 Material — The thread used for the inflatable buoyancy element shall be size E nylon or equivalent.

6.5.2 Tensile strength — When tested in accordance with FTMS 191 A, Method 5100.1, the tensile strength of the thread shall be at least 37.8 N at 21 ± 2 °C (see 7.6.7.1).

6.6 Non-metallic non-fabric items — Upon temperature cycling and when tested in accordance with Annex U, each specimen for each of the non-metallic non-fabric items or fittings shall

a. retain its physical characteristics, and

b. operate in the manner for which it is designed.

6.7 Metallic items — Metallic items shall

a. be made of corrosion resistant material or be protected against corrosion, and

b. meet the corrosion requirements in 5.6.

6.8 Rot — Materials shall not support fungal growth in accordance with BS 14119:2003, *Testing of textiles, Evaluation of the action of microfungi*.

6.9 Oral inflation

6.9.1 General

6.9.1.1 Each flotation chamber of the inflatable buoyancy element shall be capable of being inflated by blowing into a mouthpiece.

6.9.1.2 When tested in accordance with Annex P, P.6, the mouthpiece shall be readily accessible with the suit system donned, and shall not interfere with the face.

6.9.2 Oral inflation valve

6.9.2.1 Opening pressure — When tested in accordance with Annex V, V.2, the opening pressure of each oral inflation valve shall not exceed 3.03 kPa.

6.9.2.2 Leakage — When tested in accordance with Annex V, V.3, each oral inflation valve shall not leak when back pressure throughout a range of 0 kPa to 69.0 kPa is applied, as per Federal Aviation Administration TSO C13f.

6.9.2.3 Joint integrity — When tested in accordance with Annex V, V.4, the joints between the oral inflation valve and the oral inflation tube as well as between the oral inflation tube and the flotation chamber shall not fail.

6.10 Mechanical inflation

6.10.1 Mechanical inflation valve

6.10.1.1 Air flow — When tested in accordance with Annex W, W.2, the air flow through the mechanical inflation valve shall be at least 4 L/min.

6.10.1.2 Leakage — When tested in accordance with Annex W, W.3, the mechanical inflation valve shall not show a loss of pressure greater than 1.3 mm of water at the end of 1 min and 2.5 mm of water at the end of 1 h.

6.10.1.3 Joint integrity — When tested in accordance with Annex W, W.4, the joint between the valve and the flotation chamber shall not fail.

6.10.2 Gas cylinders

6.10.2.1 General

6.10.2.1.1 Each flotation chamber of the inflatable buoyancy element shall be equipped with a gas cylinder containing carbon dioxide or other inert gas for inflation purposes. See 6.1.2.1.

6.10.2.1.2 Each mechanical inflation mechanism shall

a. have a pull cord assembly that extends 38 to 76 mm below the edge of the inflatable buoyancy element, and

b. be attached to a red knob or tab having rounded edges with easily gripped handle.

6.10.2.2 Cylinder — Each gas cylinder shall meet the requirements from either ANSI/UL 1191-2011, SAE AS6011, MIL-PRF-25369 D (1) or equivalent.

6.10.2.3 Pull cord strength — When tested in accordance with Annex X, X.2, the pull cord shall not fail or separate from the gas inflation mechanism.

6.10.2.4 Inflator pull cord operating force — When tested in accordance with Annex X, X.3, the force applied to the pull cord to activate the gas inflation mechanism, puncture the gas cylinder and release the gas contents shall not exceed 66.7 N.

6.10.2.5 Proof pressure

6.10.2.5.1 Hydrostatic — When tested in accordance with Annex X, X.4, the mechanical inflation means shall not deform or leak when subjected to a hydrostatic pressure.

6.10.2.5.2 Air — When tested in accordance with Annex X, X.4, the mechanical inflation means shall not leak when subjected to 13.8 kPa of air pressure and shall not lose more than 3.5 kPa when subjected to 275.8 kPa of air pressure.

6.11 Flotation chambers

6.11.1 Deflation

6.11.1.1 General

6.11.1.1.1 When tested in accordance with Annex P, P.6, each flotation chamber shall be capable of being deflated by the wearer.

6.11.1.1.2 Accidental deflation of the flotation chamber shall not be possible.

6.11.1.1.3 When tested in accordance with Annex P, P.6, each flotation chamber shall be capable of being re-inflated by the wearer using oral or mechanical inflation following deflation.

6.11.2 Operating temperature — When tested in accordance with Annex Y, Y.2, each flotation chamber shall inflate by oral and mechanical inflation.

6.11.3 Burst pressure — When tested in accordance with Annex Y, Y.3, each flotation chamber shall not burst.

6.11.4 Over pressure — When tested in accordance with Annex Y, Y.4, each flotation chamber shall withstand an inflation pressure of at least 69.0 kPa.

6.11.5 Leakage — When tested in accordance with Annex Y, Y.5, each flotation chamber shall not lose more than 3.4 kPa.

6.12 Floating characteristics — See 5.17 for suit system requirements.

6.13 Vertical positioning — See 5.17.4 for suit system requirements.

6.14 Impact of jumping — When tested in accordance with Annex T, the inflatable buoyancy element shall

a. remain attached,

b. not result in injury to the test subject, and

c. not be damaged.

6.15 Flotation buoyancy — See 5.15 for suit system requirements.

6.16 Survivor locator light — See 5.9 for suit system requirements.

6.17 Colour of suit system exterior — See 5.7 for suit system requirements.

6.18 Flame exposure —The inflatable buoyancy element and package shall be constructed of material meeting the flammability requirements of 14 CFR 25, Appendix F, Part I, [Amendment 25-142, effective April 18, 2016]. The definition and use of parts that are considered small parts (e.g., oral inflation tubes, clips, etc.) that would not contribute significantly to the propagation of a fire shall be approved in advance by the certification office to which this test data is to be submitted. See 5.3 for suit system requirements. When tested in accordance with the US FAR Part 25 Section 25.853, Appendix F, Part I (a)(1)(iv) and part I (b)(5), Amendment 25-111, Effective 9/2/2003, the exterior fabric of the suit system shall pass the burn rate.

7 Testing

7.1 Sampling

7.1.1 Test subjects

7.1.1.1 When testing to meet the requirements of this standard, each suit system shall be tested by selecting two subjects from each of the six height and body mass categories detailed in Table 3. At least 12 test subjects shall be tested for any one test unless otherwise specified by the test method. Of the 12 subjects tested, both genders shall be represented with no more than 2/3 of the subjects from one of the genders. Within each body mass category, one of the two subjects shall be less than or equal to the mean height for that category and one shall be greater than or equal to the mean height in that category (see Mean heights in Table 3). Furthermore, the two subjects shall differ in height at least 1.5 times the standard deviation of the heights for that category (see Minimum height difference in Table 3).

Table 3

Test subject selection criteria

Category	Body mass kg	Mean height cm	Minimum height difference cm
1[a]	< 59.6	160.8	10
2	59.6 - 66.9	166.0	11
3	67.0 - 73.7	169.9	11
4	73.8 - 81.9	172.1	12
5	82.0 - 93.3	175.7	14
6[b]	> 93.4	178.7	15

[a] Boundaries are also placed on the mass ranges of the subjects in these two categories. Of the two subjects in Category 1, one must have a body mass between 51.5 and 55.1 kg and the other must be between 55.1 and 59.6 kg. The differences in height for the subjects also apply and the values are listed in Table 3.

[b] Boundaries are also placed on the mass ranges of the subjects in these two categories. For Category 6, one subject must have a body mass between 93.4 and 104.0 kg and the other must be between 104.0 and 115.5 kg. The differences in height for the subjects also apply and the values are listed in Table 3.

7.1.1.2 Unless otherwise specified by the test method, all tests shall be completed with subjects who have had no previous training with helicopter passenger transportation suit systems.

7.1.1.3 Sizing of suit systems for each subject shall be pursuant to the manufacturer's instructions.

7.1.1.4 Test subjects shall be provided with the manufacturer's instructions on the donning and operation of the suit system.

7.1.2 Suit system components — Unless otherwise specified by the test method, all tests with the suit system shall be performed with all integral and attached suit system components stowed or used as per manufacturer instructions.

7.1.3 Anomalous test results — Unless otherwise specified by the test method, all samples (or suit systems required by the test method) shall pass all tests. If, however, a failure in any test is deemed by the test house to be caused by either a problem with the test apparatus or the test subject rather than the sample or the suit system, this result may be discarded and replaced with another test on an equivalent sample or subject of the same size range as the original test. This anomaly shall be fully documented including a detailed explanation of the need for the retest.

7.2 Seam integrity

7.2.1 Breaking strength — Test in accordance with ISO 13934-1:2013, *Textiles - Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method*.

Samples may be taken directly off suit system samples or prepared separately using the same materials and construction methods.

7.2.2 Water penetration — Test in accordance with ISO 811:2018. Select one specimen of each seam type for testing.

7.3 Exterior fabric integrity

7.3.1 Breaking strength — Test in accordance with ISO 13934-1:2013, *Textiles - Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method*.

7.3.2 Tearing strength — Test in accordance with ISO 13937-4:2000, *Textiles - Tear properties of fabrics - Part 4: Determination of tear force of tongue-shaped test specimens (Double tear test)*.

7.3.3 Abrasion resistance — Test in accordance with ISO 12947-2 using a Martindale abrasion tester with a load of 12 kPa applied to the sample holder and a standard wool worsted abradant. The sample should be set at breakdown greater than 100,000 rubs.

7.3.4 Water penetration — Test in accordance with ISO 811:2018, *Textiles Determination of Resistance to Water Permeability – Hydrostatic Pressure Test*. Select one exterior fabric specimen for testing.

7.4 Flame exposure — Test in accordance with ISO 15027-3, 3.5 *Flammability test*. Select one suit system for testing.

7.5 Colour of suit system exterior — Test in accordance with CIE 015.2:2004, 3rd Edition. Select two specimens of each principal exterior fabric for testing. Measure the colour of the material samples with the procedures defined in CIE 015.2:2004, 3rd Edition, with polychromatic illumination D_{65} and 45/0 geometry and 2° standard observer. The specimen shall have a black underlay with reflectance of less than 0.04. Condition the specimens for at least 24 h at 20 ± 2 °C and 65 ± 5% relative humidity. If the test is carried out in other conditions, conduct the test within 5 min after withdrawal from the conditioning atmosphere. Record the chromaticity coordinates and luminance factor for each sample.

7.6 Inflatable buoyancy element

7.6.1 Accelerated aging

7.6.1.1 Samples that are to be aged prior to testing for specific physical properties are specified in the test method. In those instances, age the samples in accordance with FTMS 191 A, Method 5850. After aging, proceed as follows:

7.6.1.1.1 Expose the samples to a temperature of 70 ± 2 °C for 168 h. Allow the samples to cool to 21 ± 2 °C for at least 16 h and no more than 96 h. At the end of the cooling period, perform the required test.

7.6.2 Coated fabrics

7.6.2.1 Tensile strength after aging — Following the accelerated aging of samples in accordance with 7.6.1, test the tensile strength of the coated fabric in accordance with FTMS 191 A, Method 5100.1. Perform the test at 24 ± 2 °C and 60 ± 2 °C. Pneumatic grips may also replace the mechanical grips to hold the test samples when performing the test. Select five specimens from the warp direction and five specimens from the weft direction for testing.

7.6.2.2 Tear strength after aging — Following the accelerated aging of samples in accordance with 7.6.1, test the tear strength of the coated fabric in accordance with ASTM D5587. Perform the test at 25 ± 2 °C. Select five specimens from the warp direction and five specimens from the weft direction for testing.

7.6.2.3 Coat adhesion strength after aging — Following the accelerated aging of samples in accordance with 7.6.1, test three specimens in accordance with FTMS 191 A, Method 5970. Perform the test using a separation rate of 51 to 64 mm/min at 21 ± 2 °C.

7.6.2.4 Gas permeability — Test in accordance with BS 6F 100.

7.6.3 Cemented seams

7.6.3.1 Shear strength after aging — Following the accelerated aging of samples in accordance with 7.6.1, test the shear strength of the cemented seams in accordance with FTMS 191 A, Method 5100.1. Perform the test at 24 ± 2 °C and 60 ± 2 °C. Test each seam type.

7.6.3.1.1 Samples shall consist of two strips of material with a maximum width of 51 mm and a maximum length of 127 mm. Bond the strips together along the width with an overlap of 19 mm maximum. Place the free ends in the test apparatus described in FTMS 191 A, Method 5100.1 and separate at a rate of 305 ± 13 mm/min. Samples may be multi-layered to protect against premature failure and may be gripped across the full width when performing the test. Pneumatic grips may replace the mechanical grips to hold the test samples when performing the test. Report the average value of two samples.

7.6.3.2 Peel strength after aging — Following the accelerated aging of samples in accordance with 7.6.1, test the peel strength of the cemented seams in accordance with FTMS 191 A, Method 5960. Perform the test using a separation rate of 51 to 64 mm/min at 21 ± 2 °C. Select five specimens for testing. Test each seam type.

7.6.4 Heat-sealed seams

7.6.4.1 Shear strength after aging — Test the shear strength of the heat-sealed seams in accordance with FTMS 191 A, Method 5100.1. Perform the test at 21 ± 2 °C and 60 ± 2 °C. Test each seam type.

7.6.4.1.1 Samples shall consist of two strips of material with a maximum width of 51 mm and a maximum length of 127 mm. Heat seal the strips together along the width with an overlap of 19 mm maximum. Heat-sealed seams shall have a minimum width bead of 3 ± 0.8 mm with the heat seal 6 mm from each end. Place the free ends in the test apparatus described in FTMS 191 A, Method 5100.1 and separate at a rate of 305 ± 13 mm/min. Samples may be multi-layered to ensure against premature failure and may be gripped across the full width when performing the test. Pneumatic grips may replace the mechanical grips to hold the test samples when performing the test. Report the average value of two samples.

7.6.5 Seam tape

7.6.5.1 Tensile strength — Test the tensile strength of the fabric used for the seam tape in accordance with FTMS 191 A, Method 5100.1. Pneumatic grips may replace the mechanical grips to hold the test samples when performing the test. Select two specimens for testing.

7.6.6 Webbing

7.6.6.1 Tensile strength — Test the tensile strength of the webbing in accordance with FTMS 191 A, Method 5100.1. Pneumatic grips may replace the mechanical grips to hold the test samples when performing the test. Select two specimens for testing.

7.6.7 Thread

7.6.7.1 Tensile strength — Test the thread in accordance with FTMS 191 A, Method 5100.1. Perform the test at 24 ± 2 °C. Pneumatic grips may replace the mechanical grips to hold the test samples when performing the test. Select two specimens for testing.

7.7 Test clothing

7.7.1 Test clothing consists of medium weight cotton socks, cotton underwear (briefs), cotton t-shirt and standard weight, uninsulated long-sleeve cotton or poly/cotton blend coveralls. Cotton blends shall contain 65% polyester, 35% cotton coveralls.

7.8 Underwater Escape Simulator (UES)

7.8.1 The UES shall be equipped with an emergency retrieval system that can raise the device to the surface, and if necessary, to the side of the pool with occupants still inside – including during a power failure. The UES shall also be equipped with:

a. high-backed seats similar in size and type to those found on common commercial helicopter;

b. seating such that a person can exit from an aisle seat;

c. four-point harness seat restraint systems and a system for releasing occupants in an emergency should the harness fail to open;

d. a means of stopping the rotation in an emergency;

e. exits similar to those found on common commercial helicopter.

7.9 Thermal manikin

7.9.1 A thermal manikin shall be constructed so that it is possible to control, measure and record temperatures and power inputs, and such that it can be immersed in water without causing failure in the electrical system if water leaks inside the outer clothing.

7.9.2 The thermal manikin shall have at least nine segments and be able to be dressed in test clothing and Helicopter passenger transportation suit systems (HPTS).

7.9.3 Each thermal manikin segment shall be capable of being controlled at a programmable uniform temperature and be able to calculate segmental heat loss.

8 Labelling

8.1 The suit system shall be labelled[8] with at least the following information:

Sizing information, including sizing range;

Manufacturer’s name;

Date of manufacture of the suit system;

Model size;

Lot number;

Serial number;

Standard designation.

[8] Users of this standard should be aware that Transport Canada, Airworthiness, the approval authority for helicopter passenger transportation suit systems in Canada, requires additional markings to be on the suit system as a result of any approval granted. These include, for example, the approval number, approval information, the identification of the administration that approved it and any operational restrictions. Information on the approval of helicopter passenger transportation suit systems and Transport Canada requirements, including testing by designated laboratories, may be obtained from Transport Canada, Civil Aviation Directorate. Transport Canada, Airworthiness can be contacted at Standards Branch, AART 330 Sparks Street Transport Canada, Place de Ville, Tower C (AARTC) Ottawa, Ontario K1A 0N5.

8.2 Labelling information shall consist of pictograms, written text combined with pictograms or text alone.

8.3 Labelling information shall be simple and obvious.

8.4 All written text shall be in both official languages.

8.5 Lettering shall be a minimum of 5.6 mm high with a minimum stroke width of 1.2 mm.

9 Marking and placards

9.1 Each suit system shall contain information marking or a placard that states the configuration in which the suit system shall be worn.

9.1.1 Information on the donning procedure and operational use shall be simple, obvious and shall consist primarily of pictograms with a minimum use of words.

9.2 All written text shall be in both official languages.

9.3 Lettering shall be a minimum of 5.6 mm high with a minimum stroke width of 1.2 mm.

9.4 The marking or placard provided for each suit system and inflatable buoyancy element shall be displayed in a conspicuous place and shall not be easily erased, disfigured, obscured or detached, as appropriate.

10 Instructions for use provided by the manufacturer

10.1 Instructions to be provided with each suit system shall include:

a. complete sizing and fit testing instructions;

b. the donning and operational use of the suit system and its components;

c. detailed instructions for each component to be interchanged, when the suit system provides for the interchange of specific components; and

d. the type of hard-soled, non-slip footwear to be used if the boot or shoe is not incorporated with the suit system.

10.2 Instructions shall be simple and obvious and consist of pictograms, written text combined with pictograms or text alone.

10.3 All written text shall be in both official languages.

11 Care and maintenance of suit systems

The manufacturer shall provide instructions and a schedule for the care and maintenance of suit systems to maintain their serviceability.

Annex A
(informative)

Federal and provincial acts and regulations applicable to helicopter passenger transportation suit systems (see 2.2) [9, 10 and 11]

A.1 Federal regulations

Canada Oil and Gas Operations Act (R.S.C., 1985, c. O-7) (including amendments)

Canada Oil and Gas Geophysical Operations Regulations (SOR/96-117)

Canadian Aviation Regulations — Part VI — General Operating and Flight Rules — Regulations: Subpart 2 — Operating and Flight Rules — 602.62 Life Preservers and Flotation Devices

Canadian Aviation Regulations — Part VI — General Operating and Flight Rules — Regulations: Subpart 2 — Operating and Flight Rules — 602.63 Life Rafts and Survival Equipment — Flights over Water

Canadian Aviation Regulations — Part V — Airworthiness — Standards: Chapter 551 — Aircraft Equipment and Installation Section: Subchapter F Emergency Equipment — 551.401 Life Saving Equipment Over Water — Life Preservers

Canadian Aviation Regulations — Part V — Airworthiness — Standards: Chapter 551 — Aircraft Equipment and Installation Section: Subchapter F Emergency Equipment — 551.407 Aircraft Passenger Transportation Suit Systems.

A.2 Provincial regulations

A.2.1 Nova Scotia

Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation

Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act

A.2.2 Newfoundland and Labrador

Canada-Newfoundland and Labrador Atlantic Accord Implementation Act

Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act

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[9] The regulations listed are subject to revision by the relevant authority. It is the responsibility of the user to consult the relevant authority to confirm the current regulations. The information provided about the regulations is for information only. In case of conflict, the text of the regulation takes precedence.

[10] The requirements in jurisdictions other than those listed above will be added, as information becomes available in future revisions or amendments to this standard or both.

[11] This list is provided for information only and may not be complete. Please advise the CGSB if any other regulation that references this standard does not appear on this list.

Annex B
(normative)

Test method for water penetration before and after flame exposure

B.1 Summary of method — This test method is conducted to determine if the suit system has sustained damage, which results in water leakage, following the flame exposure test specified in 5.3.2.

B.2 Sampling

B.2.1 Suit system — Select one suit system sized for the test subject. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

B.3 Equipment — The following equipment is required:

a. A pool or tank containing water that is sufficiently deep to allow a subject wearing the suit to float vertically.

b. Undergarments of a colour and material that will darken when wet clearly showing the location of any water entering the suit system during the test.

B.4 Preparation — The following conditions shall apply.

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

b. If the suit system has a detachable liner, remove the liner prior to the leak test.

B.5 Procedure

B.5.1 Water penetration prior to flame exposure

B.5.1.1 The subject shall don the undergarments and the suit system and gently enter the swimming pool or tank.

B.5.1.2 The subject shall remain in a vertical position, such that the water level is 15 mm below any seal openings (including wrists) for a period of 2 min.

B.5.1.3 The subject shall exit the water at the end of the 2 min period and carefully remove the suit system with assistance to avoid dripping water on the undergarments.

B.5.1.4 Examine the undergarments for areas of water penetration. Photograph the test subject wearing the undergarments such that any wet areas are clearly visible in the photographs.

B.5.2 Flame exposure

B.5.2.1 Thoroughly dry the suit system and the undergarments used in B.5.1 and subject it to the flame exposure required in 5.3.2.

B.5.3 Water penetration following flame exposure

B.5.3.1 The subject shall don dry undergarments and the suit system used in B.5.2 and gently enter the swimming pool or tank.

B.5.3.2 Repeat the procedure in B.5.1.2 and B.5.1.3.

B.5.3.3 Examine the undergarments for areas of water penetration. Photograph the test subject wearing the undergarments from the same distance and at the same angles as in B.5.1.4 such that any wet areas are clearly visible in the photographs.

B.6 Calculation

B.6.1 Compare the wet areas in the photographs from B.5.1.4 and B.5.3.3. Calculate and record the difference between the wet areas in the photographs taken in B.5.1.4 and B.5.3.3.

Annex C
(normative)

Test method for kerosene-type fuel exposure

C.1 Summary of method — This test method is intended to assess the exterior fabric and seams of the suit system for defined minimum performance requirements for breaking strength, tearing strength, water penetration, and the exhibition of cracking or swelling when exposed to kerosene-type fuel.

C.2 Sampling

C.2.1 Specimens — The following specimen requirements shall apply:

a. When testing the exterior fabric for:

   i. Breaking Strength —1 specimen 500 mm x 150 mm warp orientation and 1 specimen 500 mm x 150 mm weft orientation

   ii. Water Penetration — 1 specimen 150 mm x 150 mm

b. When testing each type of seam for:

   i. Breaking Strength —1 specimen 500 mm x 150 mm warp orientation and 1 specimen 500 mm x 150 mm weft orientation

   ii. Water Penetration —1 specimen 150 mm x 150 mm

c. Samples can be taken directly off suit system samples or samples may be prepared separately using the same materials and construction methods.

C.3 Equipment — The following equipment is required:

a. Kerosene-type fuel meeting DEF STAN 91-091, ASTM D1655, or CAN/CGSB-3.23;

b. A container suitable to the purposes described below.

C.4 Conditioning

C.4.1 Immerse the exterior fabric specimens and specimens of each seam type in kerosene-type fuel for a period of 6 h. After removal from the container, remove any surface fuel by wiping prior to proceeding.

C.4.2 Examine the samples for cracking or swelling.

C.5 Procedure — Select the appropriate number of conditioned samples and specimens for the tests specified, and proceed to testing as follows:

a. Each type of seam for:

   i. Breaking strength in accordance with CAN/CGSB-4.2 No. 32.2-M89 (Extended 1997);

   ii. Water penetration in accordance with CAN/CGSB-4.2 No. 26.1-M88 (Reaffirmed 2001); and

b. The exterior fabric for:

   i. Breaking strength in accordance with CAN/CGSB-4.2 No. 9.2-M90 (Reaffirmed 2004)

   ii. Water penetration in accordance with CAN/CGSB-4.2 No. 26.1-M88 (Reaffirmed 2001).

Annex D
(normative)

Test method for zippers

D.1 Summary of method — This test method is intended to assess the minimum performance of primary sealing zippers used in suit systems. Zippers are exposed to salt spray, fuel, and heat while folded as in storage before being tested to assess forces required to open and close, for strength and resistance to leakage.

D.2 Sampling — Select samples for testing as follows:

a. Eight zippers at least 750 mm long

b. Two zippers at least 305 mm long.

D.3 Equipment — The following equipment is required:

a. A water tank

b. A temperature chamber

c. A temperature-controlled atomization chamber

d. Equipment as described in ASTM D2062

e. Kerosene-type fuel meeting DEF STAN 91-091, ASTM D1655, or CAN/CGSB-3.23

f. A wire mesh fixture 300 mm in length and 125 mm in diameter

g. A wood mounting board.

D.4 Conditioning

D.4.1 Perform all tests, with the exception of the leak test, after conditioning of the zippers and allowing them to rest at the standard temperature (20 ± 2 °C) and relative humidity (65 ± 2%).

D.4.2 Condition the eight 750 mm long zippers, four in the open position and four in the closed position as follows:

a. Retain two samples in the as-received condition (one open and one closed).

b. Place two samples for 100 h in a salt spray of sodium chloride in accordance with Annex E (one open and one closed).

c. Place two samples for 24 h under a 100 mm head of kerosene-type fuel at 18 to 20 °C (one open and one closed).

d. Place two samples for 24 h at 65 °C folded in half lengthwise to form a radius of not more than 25 mm (one open and one closed).

D.5 Opening and closing force

D.5.1 Procedure

D.5.1.1 Determine the opening and closing force in newtons in accordance with ASTM D2062, Sections 14-17, *Opening and Closing of Zippers*. Conduct the opening test on the four samples conditioned in the closed position and the closing test on the four samples conditioned in the open position.

D.5.1.2 Proceed to determine the diagonal pull force.

D.6 Diagonal pull

D.6.1 Preparation — Open and mount onto a solid, flat surface, such as a wood board

a. one sample of each conditioned zipper with the left side of the zipper secured, and

b. one sample of each conditioned zipper with the right side of the zipper secured.

D.6.2 Procedure

D.6.2.1 Proceed as follows:

a. Close each zipper secured on the left side by pulling the slider at an angle of approximately 25° to the right of the line of the zipper (Figure D1 a.).

b. Close each zipper secured on the right side by pulling the slider at an angle of approximately 25° to the left of the line of the zipper (Figure D1 b.).

D.6.2.2 When closed, pull the unsecured part of each zipper at an angle of 90° to the line of the zipper away from the secured part with a force of not less than 45 N (Figure D2). Determine whether the zipper sealing surfaces for each zipper pull free.

D.6.2.3 Proceed to determine the crosswise strength.

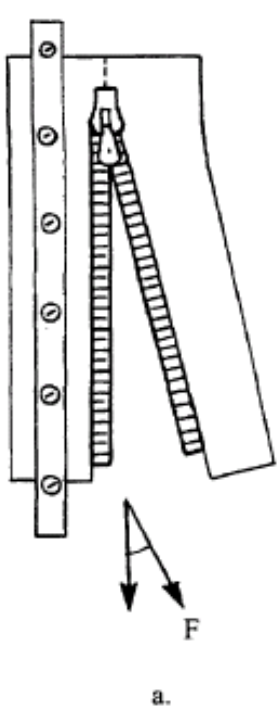

Figure D1 a.

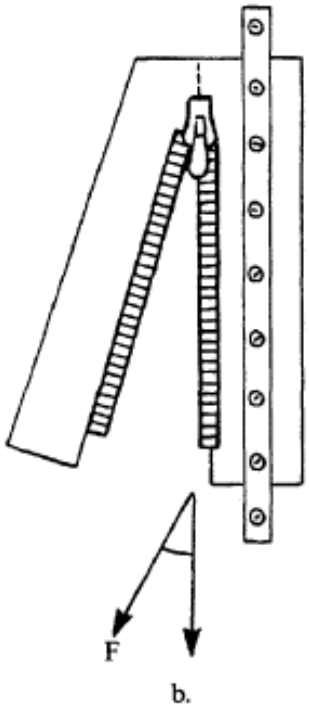

Figure D1 b.

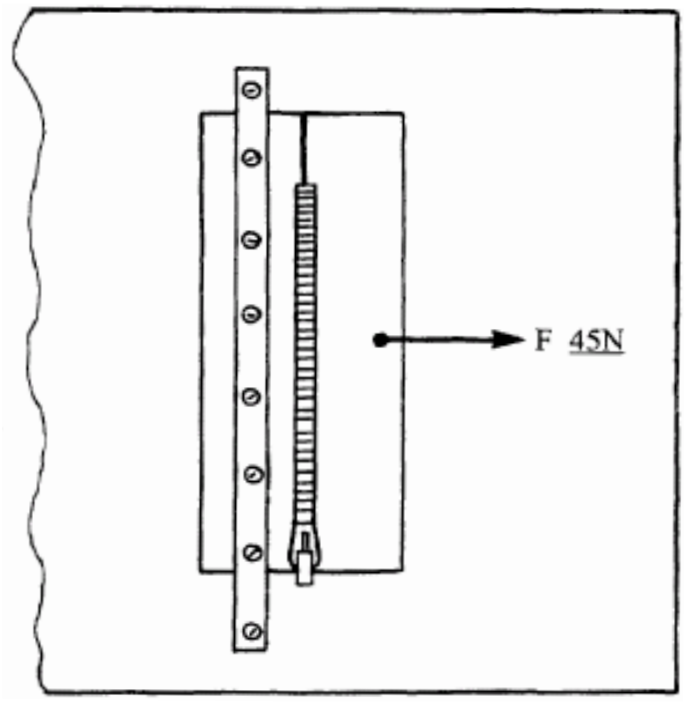

Figure D2

D.7 Crosswise strength

D.7.1 Preparation — At the conclusion of the diagonal pull test, use the four same zipper samples each exposed to one of the four conditionings in the open position to determine the crosswise strength.

D.7.2 Procedure — Determine the crosswise strength in accordance with ASTM D2061-2007, Sections 9-16 for Crosswise Strength Test only, except that a maximum load of only 440 N shall be applied. The load does not need to be applied until failure exceeding 440 N. Test each zipper at the top, bottom end and at the centre. When testing the centre of the zipper, test it at the point of folding as described in D.4.2 d.

D.8 Leakage

D.8.1 Preparation

D.8.1.1 Prepare two 305 mm long zippers as follows:

a. Glue and secure a 356 mm long piece of exterior fabric using an adhesive resistant to kerosene-type fuel to form a 127 mm diameter cylinder.

b. Seal the bottom end of the cylinder with another piece of exterior fabric.

c. Check the glued seams for tightness.

D.8.1.2 The following condition shall apply:

a. Water — Maintain the water temperature between 23 ± 5 °C in the tank.

D.8.2 Procedure

D.8.2.1 Proceed to test for water ingress as follows:

a. Place the wire mesh fixture inside each cylinder and close the zipper fully.

b. Immerse each cylinder in a water tank for a period of 1 h with the closed end of the sample facing down to a depth sufficient to submerge 90% of the zipper's effective length, that is, the portion of the zipper measured from the top of the bottom stop to the bottom of the slide when the slide is in the fully closed position.

c. Remove each cylinder from the water at the end of the 1 h immersion period and blot the inside of the cylinder with pre-weighed blotting paper to absorb any water that has ingressed. Reweigh the blotting paper. Calculate the difference in weight in grams. The difference in weight is the amount of water that has ingressed into the cylinder.

D.8.2.2 Proceed to test for water ingress following fuel exposure as follows:

a. Allow each cylinder to dry and then immerse them in a tank containing kerosene-type fuel with the closed end of the sample facing down to a depth sufficient to submerge 90% of the zipper's effective length for a period of 24 h. Remove the cylinders and blot them dry.

b. Examine the zippers for any visible signs of degradation. Proceed to test for water ingress as described in D.8.2.1.

Annex E
(normative)

Test method for corrosion

E.1 Summary of method — Suit systems may be used in an environment where corrosion may impair the performance of metal components. This test method is intended to assess the corrosion resistance of metal components used in the suit system.

E.2 Sampling

E.2.1 Specimens — Select five specimens of each metal part for testing unless otherwise specified in the test methods included in this standard.

E.3 Equipment — The following equipment is required:

a. A temperature-controlled atomization chamber.

E.4 Reagents — Sodium chloride (20% by weight) prepared from reagent grade sodium chloride (NaCl) containing no more than 0.2% solid impurities.

E.5 Preparation — The following conditions shall apply.

a. Maintain the chamber at 35 ± 1 °C during the test.

b. Maintain the salt spray solution at a specific gravity of 1.126 to 1.157 and a pH of 6.5 to 7.2 when measured at 35 ± 1 °C during the test.

E.6 Procedure

E.6.1 Place the metal parts in the chamber for 100 h, exposing the parts to the salt spray solution atomized at a rate of 10 L/m^3 per 24 h period. Measure and record the specific gravity and pH of the salt spray solution at 24 h intervals during the test.

E.6.2 Upon completion of the test, examine the metal parts for any signs of corrosion. Assess the operation of each part to determine whether it functions as intended without impairment.

Annex F
(normative)

Test method for retro-reflective material[12]

F.1 Summary of method — This test method is intended to determine the amount of retro-reflective material visible above the water line when the suit system is donned and suit components that may obscure the retro-reflective material are deployed.

F.2 Sampling

F.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

F.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

F.3 Equipment — The following equipment is required:

a. A swimming pool.

F.4 Preparation — The following condition shall apply.

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

F.5 Procedure

F.5.1 Each subject shall don the suit system with test clothing, gently enter the water, inflate the inflatable buoyancy element, if equipped, and attain a stable face-up position.

F.5.2 Measure the area of retro-reflective material visible above the water line. Measure the width of the retro-reflective material within each circumferential quadrant around each forearm.

F.5.2.1 Deploy the spray shield and any other components that may obscure the retro-reflective material and measure the area of retro-reflective material above the water line again.

F.5.2.2 In those instances where a suit system component obscures the retro-reflective material on the suit system, measure the retro-reflective material visible above the water line affixed to that suit system component.

F.6 Calculation — Calculate the average area of retro-reflective material visible above the water line.

[12] This test may be carried out at the same time as that for Flotation Characteristics – Freeboard in Annex J.

Annex G
(normative)

Test method for buddy line

G.1 Summary of method — The following test methods ensure that the buddy line can withstand required loads; can be released from the suit system under load and that the buddy line will break before a load damages the suit system. They also test the strength of the buddy line receiving point. See definitions of buddy line (see 3.3) and buddy line receiving point (see 3.4).

G.2 Sampling

G.2.2 Suit systems — Select one suit system.

G.3 Equipment — The following equipment is required:

a. Loads appropriate to test tolerances.

G.4 Procedure

G.4.1 Test the buddy line on the suit system

G.4.1.1 Apply a minimum test load of 750 N to the buddy line on the suit system and maintain the load for 3 min.

Note: All loads are to be applied at an angle of 90º to the axis of the suit sleeve or torso to which it is secured.

G.4.1.2 Observe and record any damage to the buddy line and any damage that could affect the function of the suit system.

G.4.1.3 Continue to increase the load on the buddy line and record the force at which the buddy line fails. Alternatively, apply a maximum test load of 1500 N to the buddy line on the suit system.

G.4.1.4 Observe and record at what force the buddy line parts or separates from the suit system and observe and record any damage that could affect the function of the suit system.

G.4.2 Test the suit system's buddy line receiving point

G.4.2.1 Apply a minimum test load of 750 N to the buddy line receiving point on the suit system and maintain the load for 3 min.

Note: All loads are to be applied at an angle of 90º to the axis of the suit sleeve or torso to which it is secured.

G.4.2.2 Observe and record any damage to the buddy line receiving point and any damage that could affect the function of the suit system.

G.4.2.3 Continue to increase the load on the buddy line receiving point and record the force at which the buddy line fails. Alternatively apply a maximum test load of 1500 N to the buddy line on the suit system.

G.4.2.4 Observe and record at what force the buddy line receiving point parts or separates from the suit system and observe and record any damage that could affect the function of the suit system.

G.4.3 Test the buddy line quick release

G.4.3.1 Apply a test load equal to the force recorded in G.4.1.4 to the buddy line quick release. Alternatively, apply a test load of 1500 N to the buddy line quick release.

G.4.3.1.1 The quick release is to be tested separately from the buddy line lanyard for this test. The quick release shall be secured in a manner that the load is applied in alignment with the lanyard as if it were attached to the suit system and under tension.

G.4.3.2 Manually function the buddy line quick release with one hand.

G.4.3.3 Observe and record whether the buddy line quick release functions.

Annex H
(normative)

Test method for floating life raft boarding

H.1 Summary of method — This test method evaluates the suit system's impact on the ability of wearers to board a life raft.

H.2 Sampling

H.2.1 Subjects — Select at least 12 test subjects; 10 out of 12 need to pass.

H.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

H.3 Equipment — The following equipment is required:

a. A swimming pool;

b. A TP14475 approved aviation life raft with a boarding ramp and/or ladder;

c. A SOLAS approved lifejacket and its Protocol of 1988: articles, annexes and certificates, as described in TP 14475 E.

H.4 Preparation — The following condition shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

H.5 Procedure

H.5.1 Following a brief and simple demonstration on how to board the life raft, each subject shall enter the water with the suit system fully secured and deploy the inflatable buoyancy element if fitted. The subject may adjust the suit system. The subject shall climb into the life raft via the boarding ladder with no other boarding aids within 5 min.

H.5.2 In the event that a subject is unable to board the life raft within the time allowed, the subject shall remove the suit system and, after a sufficient period of rest, the subject shall be instructed to don a SOLAS approved jacket, enter the water and board the life raft within 5 min. If the subject is unable to board the life raft, the subject is disqualified and replaced with an alternative subject from the same subject size category.

H.6 Calculation

H.6.1 Record the number of subjects that pass and do not pass.

Annex I
(normative)

Test method for spray shields

I.1 Summary of method — This test method is intended to measure the carbon dioxide levels under the spray shield when the shield is deployed.

I.2 Sampling

I.2.1 Test subjects — Select at least six test subjects for testing.

I.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

I.3 Equipment— The following equipment is required:

a. A swimming pool;

b. A fast response carbon dioxide analyzer, capable of measuring continuously the carbon dioxide level as a percentage within a continuously flowing sample. The analyzer shall have a time constant short enough to accurately measure the end-tidal carbon dioxide level.

I.4 Preparation — The following conditions shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C or above.

b. Analyzer equipment — Follow the manufacturer's instructions regarding calibration and maintenance.

I.5 Procedure

I.5.1 Each subject shall enter the pool and assume a face-up floating position.

I.5.2 Measure the carbon dioxide level within the hood continuously at a distance of 50 ± 5 mm from the nares for a period of 5 min in the deployed condition.

I.5.3 Measurement of the carbon dioxide level in the hood is to begin within 10 seconds of fully deploying the spray shield.

I.6 Calculation

I.6.1 Calculate the average level of carbon dioxide as percent by volume during each 1 min interval and record the maximum level of carbon dioxide (percent by volume) for the 5-minute period.

Annex J
(normative)

Test method for flotation buoyancy

J.1 Summary of method —This test method is intended to calculate the minimum flotation buoyancy of the suit system.

J.2 Sampling

J.2.1 Suit system — Select one suit system, the smallest suit size, with all components attached. Remove all buoyant materials not intended to be calculated as part of the minimum flotation buoyancy.

J.3 Equipment — The following equipment is required:

a. A mesh basket that is large enough to hold a suit system with an inflated inflatable buoyancy element and that is weighted to overcome the buoyancy of the suit system when placed in the basket.

b. A tank of fresh water at 23 ± 5 °C that is large enough to contain the basket submerged with its edge top 50 mm below the surface of the water.

c. A scale or load cell with an accuracy of ± 25 g that is arranged to support the mesh basket in the tank.

J.4 Procedure

J.4.1 Submerge the basket so that its top edge is 50 mm below the surface of the water. Record the mass of the submerged basket.

J.4.2 If the suit system includes any inherently buoyant materials remove them for the first measurement. Those that are to be used as a portion of the minimum buoyancy will be measured separately in J.4.6. Place all neutral or negatively buoyant suit system components in the basket with the inflatable buoyancy element inflated. Ensure that any entrapped air outside of the buoyant element is released.

J.4.3 Any necessary steps need to be taken to remove air from the suit prior to testing. Submerge the basket and manipulate the basket and suit as necessary to ensure that any additional entrapped air escapes.

J.4.4 With the top edge of the basket 50 mm below the surface of the water, record the mass of the submerged basket and the suit components. Determine the original measured buoyancy of the components by subtracting the mass of the basket plus the suit system from the mass of the basket. Correct the results to an atmospheric pressure of 101.3 kPa and a temperature of 20 °C, and calculate the buoyancy in newtons. Record this as the initial buoyancy of the suit system.

$$B_C = B_M \times \left(\frac{P}{101.3} \right) \times \left(\frac{293}{T + 273} \right)$$

where:

B_C = corrected buoyancy, in newtons

B_M = measured buoyancy, in newtons

P = pressure, in kilopascals

T = temperature, in degree Celsius

J.4.5 If the suit system contains inherently buoyant materials that have been removed in J.4.2, place this material into the basket and determine the buoyancy as above. Repeat this procedure for each different inherently buoyant material.

J.4.6 Measure the buoyancy of each type of buoyant material and adjust the contribution of each inherently buoyant material in accordance with the procedures and formula in J.5.

J.5 Calculation

J.5.1 Flotation buoyancy not using inherently buoyant materials — If no inherently buoyant materials are being used to meet the minimum flotation buoyancy, then the suit system initial buoyancy (see J.4.4) shall be used as the flotation buoyancy.

J.5.2 Flotation buoyancy using inherently buoyant materials — The contribution of the inherently buoyant materials to the flotation buoyancy of the suit system shall be calculated and adjusted for buoyancy loss over time in accordance with the following formula:

$$Bf = Bt \times \sum_{i=1}^{n} Pi \times \frac{Vi}{100}$$

where:

Bf = flotation buoyancy, in newtons

Bt = measured buoyancy of the device, in newtons (complete device minus any non-contributing foam)

Pi = percentage of buoyancy provided by the *i*th material to the total measured buoyancy of the buoyant materials (Each material with a different V-factor is measured separately). For inflatable and negative buoyancy (see J.4.2) the V-factor is 100.

The total measured buoyancy is the sum of each measured material buoyancy.

n = number of materials used in the device

Vi = V-factor of the *i*th buoyant material as determined in UL1191-2011, Section 24.3.

For neoprene materials, Vi = 100 – E*i*,

where E*i* is the buoyancy loss factor of the *i*th buoyant material as determined in UL1197-2011, Section 24.6.

Annex K
(normative)

Test method for escape buoyancy

K.1 Summary of method — This test method establishes the escape buoyancy of the suit system by measuring the total buoyancy of the suit system and subject in an inverted position in the UES (see 7.8).

K.2 Sampling

K.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

K.2.2 Suit systems — Select a suit system sized for each subject tested. The sizing of the suit system shall be in accordance with the manufacturer's instructions.

K.3 Equipment — The following equipment is required:

a. A UES (see 7.8) with a 46 cm x 55 cm exit window.

b. A UES buoyancy chair — A waterproof measuring device mounted on the UES floor, combined with a standard high-back chair employing a minimum of three compression-tension load cells between the floor and chair base, allowing for an accurate reading of underwater buoyancy measurement. The system is controlled via a computer where the sum of the three load cells is displayed and saved in a plot chart.

c. A pool and UES approved lifting device.

K.4 Preparation — The following conditions shall apply:

a. Water — Conduct the test in fresh calm water at 23 ± 5 °C.

b. A qualified UES instructor and a diver shall be present for each test. Prior to participating in this escape buoyancy testing, all subjects will receive a theoretical classroom briefing on underwater egress followed by a single submersion that includes inversion in the UES, under the supervision of a qualified UES instructor.

K.5 Buoyancy of subject wearing swimsuit in upright position

K.5.1 Procedure

K.5.1.1 Each subject wearing only a bathing suit shall enter the UES. The subject shall assume a sitting position in the UES buoyancy chair.

K.5.1.2 The UES shall then be submerged. The subject shall maintain the crash position for this entire motion until they release. When the motion of the UES has stopped, hold the position for 5 s, counted by the instructor or the diver and one of whom has the ability to signal the time to release to the test subject without touching the subject. The subject shall then exit the UES. This measurement is used in the equation K.5.1.4 as $A_{total.}$

K.5.1.3 Measure and record the buoyancy of the subject by taking an average of the buoyancy measurements from the last 2 s of the 5 s measurement period. Subtract the buoyancy of the shoes, helmet and any additional safety gear worn by the test subject. This measurement is used in the equation K.5.1.4 as $A_{equipment.}$

K.5.1.4 The variable (A) in the equation found in K.7.1 is calculated as follows:

$A = A_{total} - A_{equipment}$

K.6 Buoyancy of suit system

K.6.1 Procedure

K.6.1.1 Test subject shall don the test clothing and suit system with the detachable components in a stowed position.

K.6.1.2 The suit system shall be worn in the manufacturer recommended travel configuration as defined in section 3[13]. The subject shall enter the UES from a dry location, assume a sitting position in the buoyancy chair and be secured with a 4-point harness. The subject shall ensure the suit system is donned and sealed in accordance with the manufacturer's instructions (UES instructor shall ensure the suit system is donned and sealed as per instructions).

K.6.1.3 The test subject shall ensure feet remain on the buoyancy chair plate. Once secured by the harness, the subject shall assume the crash position with their arms over their chest and head forward as far as the properly fastened four-point harness permits.

K.6.1.4 The UES shall then be submerged and inverted to 180º. The subject shall maintain the crash position, feet on buoyancy plate, until motion of the UES has stopped. When the motion has stopped, hold position for 5 s, counted by the instructor or the diver. The subject will then exit the UES.

K.6.1.5 Measure and record the buoyancy of the subject wearing the suit system by taking an average of the buoyancy measurements from the last 2 s of the 5 s measurement period.

K.6.1.6 Repeat K.6.1.2 through K.6.1.5 two more times. Calculate the average of the results. This represents (B) in the equation found in K.7.1.

Note: If a subject releases prior to the indication from the instructor, the test may be repeated. The method can be repeated until the three measurements are completed.

K.7 Calculation

K.7.1 For each subject, calculate and record the escape buoyancy of the suit system in newtons (N) as follows:

Escape buoyancy = (B) – (A)

where:

(A) is the buoyancy of the subjects wearing a swimsuit (see K.5.1.4)

(B) is the buoyancy of the subjects wearing the suit system (see K.6.1.6).

[13] Manufacturer's instructions may allow the options for helicopter passengers to travel with the suit system partially donned, e.g. head and/or hand protection stowed and/or zipper partially open. Hence the term "travel configuration".

Annex L
(normative)

Test method for floating characteristics: freeboard, stability, righting

L.1 Summary of method — This test method evaluates the floating position of a person wearing helicopter passenger transportation suit systems by measuring freeboard, stability and righting characteristics of the suit system.

L.2 Sampling

L.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

L.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

L.3 Equipment — The following equipment is required:

a. A swimming pool.

b. Measurement tool for freeboard.

L.4 Preparation — The following condition shall apply.

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

L.5 Freeboard

L.5.1 Procedure

L.5.1.1 Each subject shall don the suit system with test clothing, gently enter the water, inflate the inflatable buoyancy element, when fitted, and adopt a face-up position in the pool with the legs together and the arms at the sides.

L.5.1.2 Measure the freeboard in millimetres for each subject.

L.6 Stability

L.6.1 Procedure

L.6.1.1 Each subject shall don the suit system with test clothing, gently enter the water, inflate the inflatable buoyancy element, when fitted, and adopt a face-up position in the pool with the legs together and the arms at the sides.

L.6.1.2 The tester shall grasp both of the test subject's shoulders and turn the subject to 90^{o} in one direction, then release. Record if the subject spontaneously returns to a face-up position without self-assistance or assistance from the tester.

L.6.1.3 Repeat L.6.1.2 in the opposite direction. Record if the subject spontaneously returns to a face-up position without self-assistance or assistance from the tester.

L.7 Righting

L.7.1 Horizontal righting

L.7.1.1 Procedure

L.7.1.1.1 Each subject, wearing test clothing, shall don the suit system and gently enter the calm water with the inflatable buoyancy element uninflated, when fitted. Each subject shall assume a face-down position, and allow the body to become limp. If the suit system does not turn the subject within 5 s, the subject shall attempt to turn face-up by rolling 180° to a stable face-up position while remaining horizontal, twisting their body and using their arms under their own power for an additional 5 s.

L.7.1.1.2 From a pre-arranged start signal, measure and record the time in seconds that it takes for each subject to be turned face-up by the suit system or to adopt a face-up position without assistance.

L.7.1.1.3 Repeat the procedure with the inflatable buoyancy element inflated when the suit system is fitted with an inflatable buoyancy element.

L.7.2 Vertical heads-up righting

L.7.2.1 Procedure

L.7.2.1.1 Use the same subjects as for determining horizontal righting. Each subject, wearing test clothing, shall don the suit system with the inflatable buoyancy element uninflated, when fitted, and perform a head first entry jump into the water with hands by their sides by leaning over the side of the pool from a height of 1 m above the water surface.

L.7.2.1.2 Measure and record the time in seconds that it takes for each subject to attain a heads-up floating position. Begin when the subject first makes contact with the water.

L.7.2.1.3 Repeat the procedure with the inflatable buoyancy element inflated when the suit system is fitted with an inflatable buoyancy element.

Annex M
(normative)

Test method for floating characteristics: vertical positioning

M.1 Summary of method — This test method evaluates the impact of a suit system on the ability of a subject to attain and maintain a vertical position in the water. Test subjects are required to achieve a vertical position and maintain that position for an established period of time.

M.2 Sampling

M.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

M.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

M.3 Equipment — The following equipment is required:

a. A swimming pool.

b. Timing device.

M.4 Preparation — The following condition shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

M.5 Procedure

M.5.1 Each subject shall don the test clothing and the suit system, enter the water and inflate the inflatable buoyancy element, if fitted. Each subject shall start this exercise in a natural flotation position and will then assume a vertical position within 1 min of a pre-arranged start signal and maintain a vertical position without assistance for a 2 min period.

M.5.2 Record the number of subjects that assumed a vertical position within 1 min and maintained a vertical position without assistance for a 2 min period. The subject is unsuccessful at completing this test if:

a. the vertical position is not assumed within 1 min of the start signal,

b. the legs rise to the water surface after achieving the vertical position and the subject is not able to resume the vertical position immediately without assistance, or

c. the legs rise to the surface of the water more than once during the 2-minute time period.

M.6 Calculation

M.6.1 Record the number of subjects that successfully and unsuccessfully complete this test.

Annex N
(normative)

Test method for angle of vision

N.1 Summary of method — This test method is intended to ensure that the suit system does not significantly impair the wearer's angle of vision.

N.2 Sampling

N.2.1 Subjects — Prequalify at least six test subjects for testing (ensure one from each category as per 7.1.1) in accordance with the procedures set out in N.5, *Pre-qualification of test subjects*.

N.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

N.3 Equipment — The following equipment is required:

a. A Bohemier perimeter scope (see figures N1 to N4). This device is a solid arc with a 1 m radius. The arc is marked in 150 mm (10°) intervals, and it is fitted with an angle measurement device so that the angle of the perimeter scope can be measured during the vertical test;

b. A swimming pool;

c. A cylinder between 2 and 3 cm in diameter and between 0.4 and 0.5 m long finished in a colour that contrasts with the background colour of the test area or a single-point source of light with an opening no larger than 3 mm.

N.4 Preparation — The following condition shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

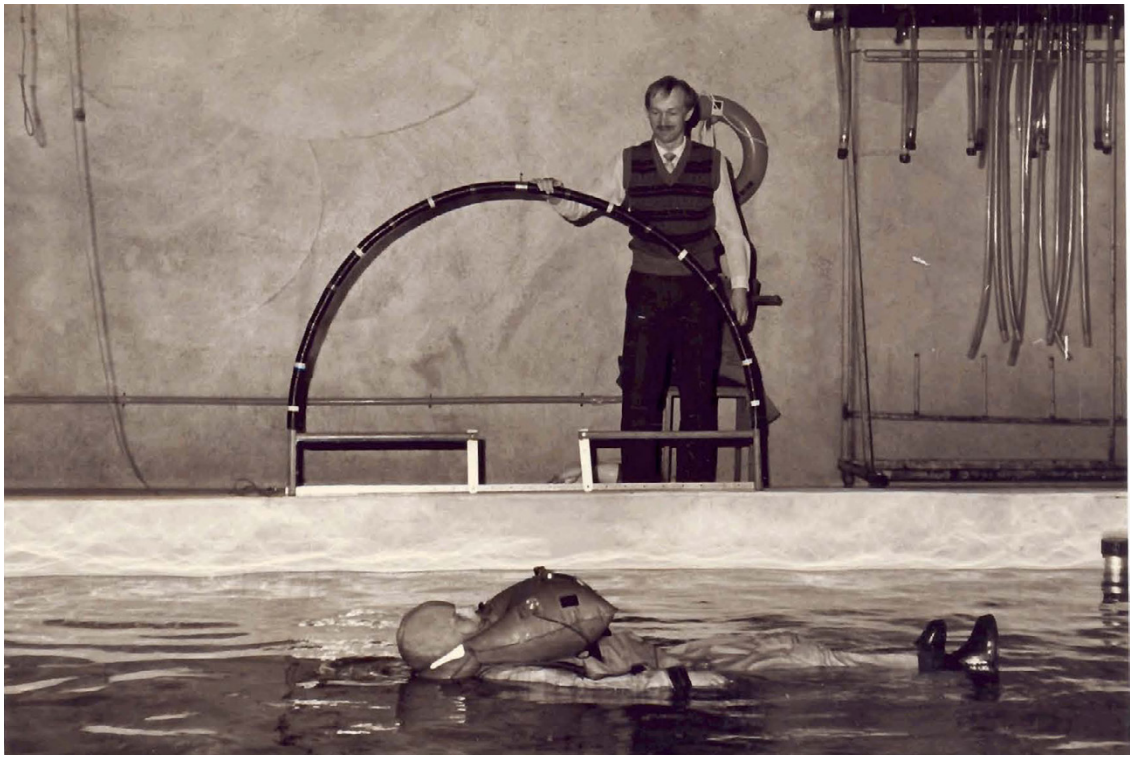

Figure N1
Bohemier perimeter scope

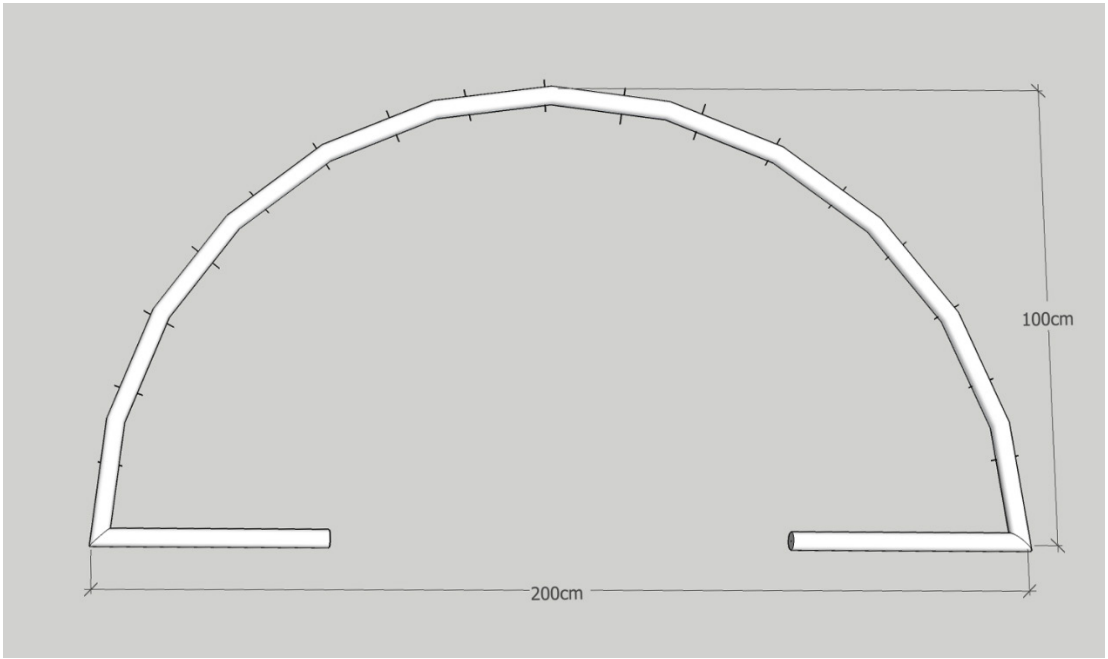

Figure N2
Bohemier perimeter scope — Lateral plane

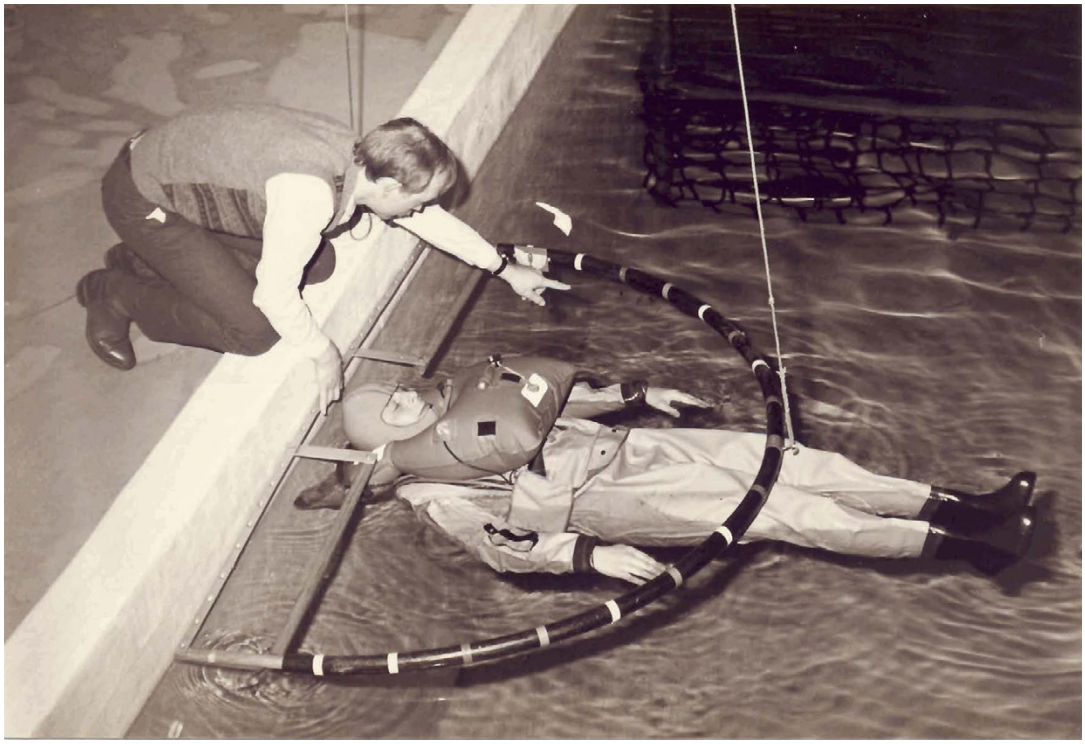

Figure N3
Bohemier perimeter scope — Horizontal plane

Figure N4
Bohemier perimeter scope — Vertical plane

N.5 Pre-qualification of test subjects

N.5.1 With each subject wearing only test clothing, seat each subject in a chair with their head perpendicular to the shoulder plane.

N.5.2 With the subject's head forming the centre of a circle, move the cylinder or light source specified in N.3 c. around the test subject at eye level at a distance of 1 m. Instruct the test subjects that they shall only move their eyes.

N.5.3 To qualify as a test subject, the subject shall be able to see the light over the full 180º arc.

N.6 Angle of vision on land

N.6.1 With each qualified subject wearing the test clothing and the suit system with the inflatable buoyancy element, if fitted, uninflated, repeat the procedure described in N.5 for the following positions:

a. Head perpendicular to the shoulder plane.

b. Head rotated 30° to the left of the perpendicular of the shoulder plane.

c. Head rotated 30° to the right of the perpendicular of the shoulder plane.

N.6.2 Determine the subject's single field of lateral vision by observing the angle in degrees that the subject can observe the cylinder on each side from the perpendicular of the shoulder plane for each of the positions.

N.7 Angle of vision in the water

N.7.1 Each qualified subject, wearing test clothing and the suit system shall enter the pool and assume a relaxed position. If the suit system has a spray shield, it shall be in the stowed position. If the suit system has an inflatable buoyancy element, it shall be inflated.

N.7.2 Using a Bohemier perimeter scope or a similar device, measure each subject's angle of vision in the lateral, vertical and horizontal planes in the normal flotation angle, the head in a normal postural position supported by the suit and eyes allowed to move.

N.7.3 Deploy spray shield, verify that subjects can see through it.

Annex O
(normative)

Test method for mobility

O.1 Summary of method — This test method is intended to ensure that the suit system does not significantly impair the wearer's mobility and thus create a hazard.

O.2 Climbing

O.2.1 Sampling

O.2.1.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

O.2.1.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

O.2.2 Equipment — The following equipment is required:

a. A vertical ladder with rungs 300 mm apart;

b. Athletic shoes sized to fit each subject.

O.2.3 Procedure

O.2.3.1 Each subject, wearing only the test clothing and athletic shoes, shall climb the vertical ladder until both of their feet are at a height of 3 m above the floor. Without pausing, the test subject shall descend the ladder until both feet are on the floor. Record the total time taken for the ascent and descent at a normal climbing pace.

O.2.3.2 Repeat O.2.3.1 and calculate the average time for the two climbing tests.

O.2.3.3 Following a minimum rest period of 5 min, each subject shall repeat the test in O.2.3.1 wearing the test clothing and suit system donned in accordance with the manufacturer's instructions.

O.2.3.4 Repeat O.2.3.3 and calculate the average of the two climbing tests with the suit system donned.

O.2.4 Calculation — Calculate the difference between the average time taken with the suit system donned and without the suit system donned. Express this result as a percentage.

O.3 Walking

O.3.1 Sampling

O.3.1.1 Subjects — Select at least 12 subjects for testing in accordance with 7.1.1.

O.3.1.2 Suit systems — Select a suit system sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

O.3.2 Equipment — The following equipment is required:

a. A smooth, wet floor surface 120 m in length with at least four 90° turns, maintained at 23 ± 5 °C;

b. Athletic shoes sized to fit each subject.

O.3.3 Procedure

O.3.3.1 Each subject shall walk the 120 m distance at a normal walking pace. The walk shall be completed twice. Record the time taken for each walk.

O.3.3.2 Following a rest period of at least 5 min, repeat O.3.3.1 with each subject having donned the suit system following the manufacturer's instructions supplied with the suit system.

O.3.4 Calculation — Calculate the difference between the average time taken with the suit system donned and without the suit system donned. Express this result as a percentage.

Annex P
(normative)

Test method for suit system component donning and use

P.1 Summary of methods — These specific test methods are intended to assess hood and seal actions, critical survival actions and rescue actions for the instances where the hand protection are worn and not worn in accordance with manufacturer's instruction. Prior to testing, specific suit system requirements and manufacturer's instructions should be reviewed and any additional suit specific tasks be documented in the test plan and included in the test procedures as required.

P.2 Sampling

P.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

P.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

P.2.3 Equipment — The following equipment is required:

a. A swimming pool;

b. A facsimile helicopter seat with a four-point harness.

P.3 Preparation — The following condition shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

P.4 Hood and seal actions

P.4.1 Procedure

P.4.1.1 Perform this test if the written manufacturer's instructions provide the option for the suit to be worn in the helicopter without the head protection donned and/or without all seals secured. These measurements are to be made out of sight of the other subjects. Proceed as follows:

a. Size and fit each subject to a helicopter passenger transportation suit system in accordance with the manufacturer's instructions.

b. Each subject shall review the manufacturer's instructions for the donning of the suit system and don the suit system.

c. Seat each subject in the facsimile helicopter seat and secure the harness.

d. Ensure that the suit system is donned in accordance with the manufacturer's instructions for travel by helicopter and that the helicopter seat harness is properly secured.

e. Each subject shall don and seal the suit system for entry into the water once with assistance and instruction.

f. Each subject shall return the suit system to the travel configuration as allowed for by the manufacturer's instructions.

g. Upon an agreed signal, the subject shall don and secure the hood and all seals.

P.4.2 Record the time in seconds taken for each subject to complete the tasks in P.4.1.1 g.

P.5 Critical survival actions

P.5.1 Procedure

P.5.1.1 Perform this test if the written manufacturer's instructions provide the option for hand protection to be worn in the helicopter. These measurements are to be made out of sight of the other subjects. Proceed as follows:

a. Size and fit each subject to a helicopter passenger transportation suit system in accordance with the manufacturer's written instructions.

b. Each subject shall review the manufacturer's instructions for the donning of the suit system.

c. Each subject shall subsequently don the suit system, including securing the seals for entry into the water as per the manufacturer's instructions.

d. Each subject shall don the hand protection where it is an integral part of the suit system or when the manufacturer's instructions require that they be worn in the helicopter.

e. Ensure that each subject dons the suit system, secures the seals for water entry and dons the hand protection in accordance with the manufacturer's instructions. Provide assistance if required.

f. Explain and demonstrate to each subject the location, deployment and activation of the suit system components to be tested.

g. Each subject shall then enter the calm water and assume a stable face-up position.

h. Upon an agreed signal, each subject shall

   i. inflate the inflatable buoyancy element, if fitted;

   ii. visually locate and manually deploy the spray shield, and

   iii. visually locate and activate or deploy any other component, which requires rapid activation or deployment upon entry into the water pursuant to the manufacturer's instructions.

i. Record the time in minutes taken by each subject to complete all the tasks in P.5.1.1 h.

P.5.1.2 These measurements are to be made out of sight of the other subjects. In the instance where the hand protection is not worn in the helicopter, proceed to test the critical survival components as follows:

a. Size and fit each subject to a helicopter passenger transportation suit system in accordance with the manufacturer's written instructions.

b. Each subject shall review the manufacturer's instructions for the donning of the suit system.

c. Each subject shall subsequently don the suit system, including secure the seals for entry into the water as per the manufacturer's instructions.

d. Ensure that each subject dons the suit system, secures the seals for water entry. Provide assistance if required.

e. Explain and demonstrate to each subject the location, deployment and activation of the suit system components to be tested.

f. Each subject shall then enter the calm water and assume a stable face-up position.

g. Upon an agreed signal, each subject shall

i. inflate the inflatable buoyancy element, if fitted;

ii. visually locate and manually deploy and don the spray shield;

iii. visually locate and activate or deploy any other component, which requires rapid activation or deployment upon entry into the water pursuant to the manufacturer's instructions; and

iv. visually locate and don the hand protection.

h. Record the time in minutes taken by each subject to complete all the tasks in P.5.1.2 g.

P.5.1.3 Proceed immediately with the testing of rescue actions (see P.6) while subjects are still in the water.

P.6 Rescue actions

P.6.1 Procedure

P.6.1.1 'Rescue Action' testing is completed immediately after the completion of 'Critical Actions' with subjects still in the water.

P.6.1.2 In the instance where the hand protection is worn to perform rescue actions, proceed to test as follows:

a. Upon an agreed signal, each subject shall proceed in the following order to

i. stow the spray shield to a position where it does not impede the subject's vision, or impede carrying out rescue action;

ii. if an inflatable buoyancy element is fitted, locate and function the deflation valve until function is verified by seeing, feeling or hearing inflation gas being expelled;

iii. if an inflatable buoyancy element is fitted, locate and function the re-inflation valve until function is verified by seeing, feeling or hearing inflation gas entering the buoyancy element;

iv. with one hand, locate the buddy line, attach it to the life raft grab line (Becket Line) and disconnect it from the suit system; and

v. with one hand, locate and use the whistle.

P.6.1.2.1 Record the time in minutes required by each subject to complete all tasks.

P.6.1.3 In the instance where the hand protection is removed to perform rescue actions and then re-donned afterward, proceed to test as follows:

a. Upon an agreed signal, each subject shall proceed in the following order:

i. Remove the hand protection;

ii. Stow the spray shield to a position where it does not impede the subject's vision, or impede carrying out rescue action;

iii. If an inflatable buoyancy element is fitted, locate and function the deflation valve until function is verified by seeing, feeling or hearing inflation gas being expelled;

iv. If an inflatable buoyancy element is fitted, locate and function the re-inflation valve until function is verified by seeing, feeling or hearing inflation gas entering the buoyancy element;

v. With one hand, locate the buddy line, attach it to the life raft grab line (Becket Line) and disconnect it from the suit system;

vi. With one hand, locate and use the whistle; and,

vii. Locate and don the hand protection.

P.6.1.3.1 Record the time in minutes required by each subject to complete all tasks.

Annex Q
(normative)

Test method for underwater egress from a helicopter

Q.1 Summary of method — This test evaluates the effect of suit system buoyancy on mobility and the tendency of suit components to be dislodged during an underwater egress from an underwater escape simulator (UES). Consideration is given to the impact on mobility from buoyancy of the suit system and the dislodging of equipment from the suit system.

Q.2 Sampling

Q.2.1 Subjects — Select at least 12 test subjects for testing who have not had UES training or experience in the last 24 months and in accordance with 7.1.1.

Q.2.2 Suit systems — Select a suit system and test clothing sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

Q.3 Equipment — The following equipment is required:

a. A UES (see 7.8) with a 46 cm x 55 cm exit window;

b. A pool and lifting device approved for use with a UES.

Q.4 Preparation

Q.4.1 Prior to participating in this escape buoyancy testing, all subjects will receive a theoretical classroom briefing on underwater egress followed by a single submersion that includes an inversion in the UES, under the supervision of a qualified UES instructor.

Note: An UES instructor will determine whether the subject is fit to continue with the testing. The UES instructor will not let the test subject continue if they are fatigued, overtly injured, or ill.

Q.4.2 Each subject shall become familiar with the test procedure prior to testing.

Q.4.3 Conduct the test in calm fresh water at 23 ± 5 °C.

Q.4.4 Prior to each run, ensure all suit components are stowed in accordance with the manufacturer's instructions and there is no damage to the suit.

Q.4.5 Each egress shall be video recorded from a location inside the UES, the test subject's egress shall be clearly visible in the recording.

Q.4.6 A qualified UES instructor and a diver shall be present for each test.

Q.5 Procedure

Q.5.1 Secure the test subject with a four-point harness in an aisle seat with an open exit.

Q.5.2 A qualified UES instructor shall observe the test from inside the UES.

Q.5.3 Lower the UES such that the test subject is completely submerged and inverted 180° ± 10° (see figure Q3).

Q.5.4 The test subject shall disengage the harness/seat belt and egress out the exit from the aisle seat and proceed to the surface.

Q.5.5 For each test subject repeat steps from Q.5.1 to Q.5.4 twice, once with the UES inverted to approximately 45° and once inverted to approximately 225°[14]. Two of the three progressions may be completed in the same egress direction (right or left), and the remaining egress progression shall be completed in the opposite direction (see figures Q2 and Q4).

Q.5.6 Record the number of instances where

a. any one of the test subjects requires assistance in any of their egresses, or any component completely deploys or becomes fully dislodged or impedes egress or there is damage to the suit during egress.

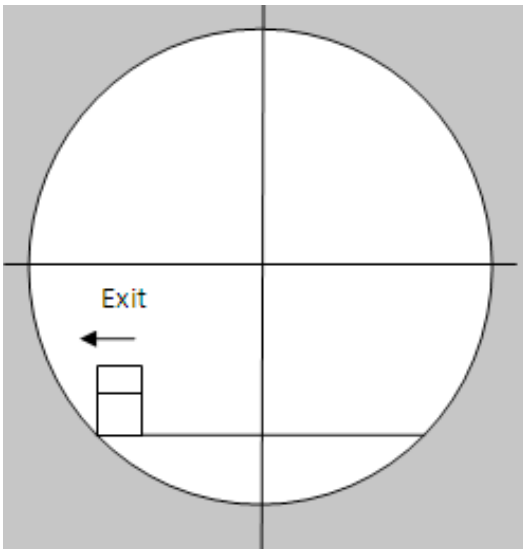

Figure Q1
Start position

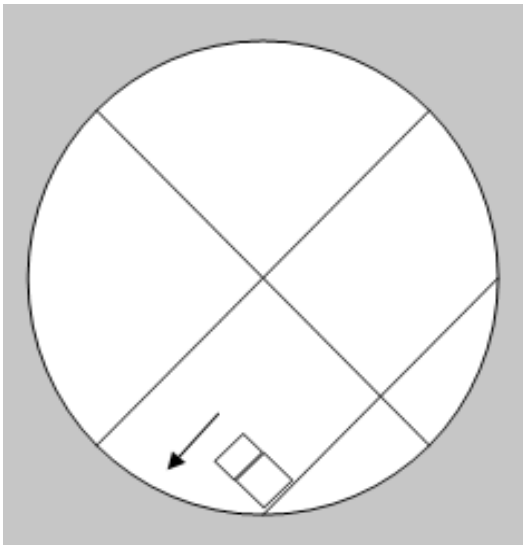

Figure Q2
45 degree

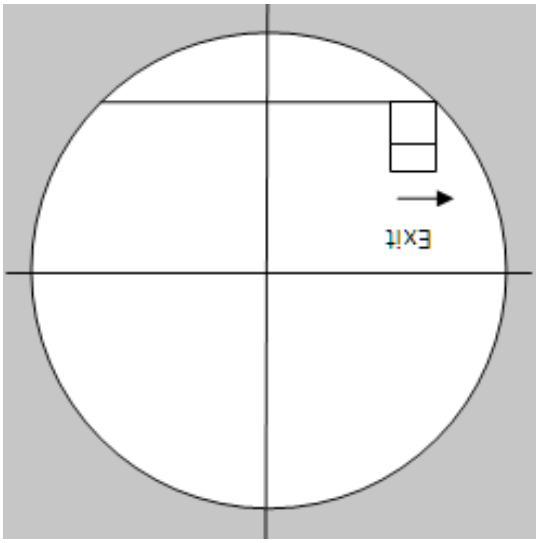

Figure Q3
180 degree

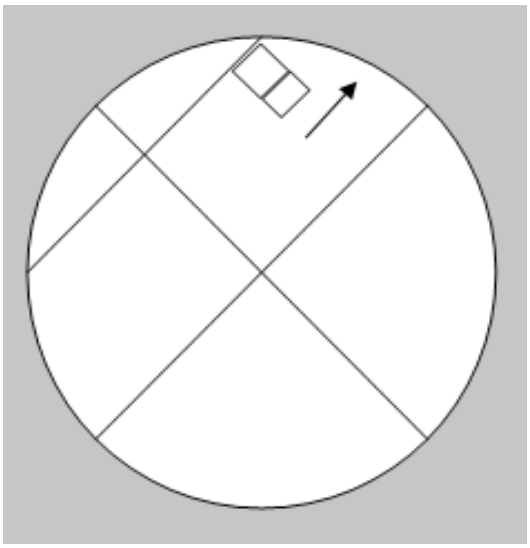

Figure Q4
225 degree

[14] The angles for egress are approximate because the UES may not be capable of stopping at such specific angles. The intention is that an egress be completed in both the downward and upward directions so that the subject is travelling against and with the buoyancy effects of the suit, respectively.

Annex R
(normative)

Test method for water ingress

R.1 Summary of method — This test method determines the amount of water that enters the suit system following underwater egress from a UES and following a 60-minute exposure to wind, waves and rain. A six-hour water ingress amount is then estimated by extrapolation from the results of the 60 minute exposure and this amount is then combined with the UES egress water ingress amount for a total. This total amount of water is then introduced into the suit system when determining its thermal performance in Annex S.

R.2 Sampling

R.2.1 Subjects — Select at least 12 human subjects for testing in accordance with 7.1.1.

R.2.2 Suit systems — Select a suit system sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

R.3 Equipment — The following equipment is required:

a. A platform scale capable of measuring 250 ± 0.020 kg;

b. A 80 cm x 100 cm tray to catch dripping water;

c. A pool area with wind, wave and rain simulation capability:

   i. wind speed simulator shall be capable of simulating winds between 50 and 70 km/h at the location of the subjects in the pool;

   ii. wave generator shall be capable of generating standing waves of 0.75 m, or waves that provide a similar level of challenge to persons in the water with periodic breaking waves that promote wind-driven spray;

   iii. rain generator shall be capable of simulating a heavy rain over the test zone, with a flow rate of 600 L/h for each UL 60507 certified rain nozzle used;

d. A UES (see 7.8) with a 46 cm x 55 cm exit window;

e. A SOLAS approved 10 to 14-person life raft;

f. A tethering system that positions the subject's feet towards the wind and wave source.

   i. Tether each subject to a rope that has been secured across the width of the pool perpendicular to the direction of wind and waves using 10 mm to 12 mm diameter surgical tubing between 1.0 and 1.5 m long such that subjects are at least 1 m apart and 1.5 m from the sides of the pool (see figure R1B).

R.4 Preparation — The following conditions shall apply:

a. Start the tests in calm fresh water at 23 ± 5 °C.

b. The suit system shall be dry before initiating the test.

c. Pool and equipment set up as per figure R1.

d. A qualified UES instructor, rescue diver and hoist operator shall be present.

R.4.1 Each subject shall be trained in underwater egress. Training shall consist of a classroom briefing and a practice run, inverted in the UES, conducted by a qualified UES instructor.

R.4.2 Each subject shall become familiar with the test procedure prior to testing.

R.5 Water ingress

R.5.1 Procedure for water ingress for the ditching and vital actions (DVI)

R.5.1.1 With suit systems properly donned, have each subject slowly enter the pool via a ladder in order to saturate the exterior of the suit. Ensure all seals remain out of the water. Using a warm water hose, spray any areas of the suit system not immersed in water. Continue this procedure for 3 min, and then have the subjects exit the water via the ladder.

R.5.1.2 Once on the pool deck, have the subjects perform the following steps:

R.5.1.2.1 Method one:

a. Where hand protection is not integral to the suit system, the subject shall remove the hand protection and hold inverted to drain excess water.

b. The subject shall stand for a period of 2 min to allow excess water to drain from the exterior of the suit system.

c. During this time the subject shall perform two series of forward and side bends and squats, holding each position for 10 s, to promote trapped water in the exterior of the suit to drain.

R.5.1.2.2 Method two:

For some suit designs, the method described in R.5.1.2.1 may not be effective. If necessary, the following method is also acceptable for measuring water:

a. Prior to the test, the mass of each layer of each suit is to be measured and recorded.

b. After the DVI test method, the subject exits the pool and the exterior of the suit is toweled dry.

c. When the exterior of the suit is sufficiently dryed so that the inner garments will not be contaminated with additional water, the suit can be removed. Any loose water contained within the suit is to be collected.

d. The watertight garment, insulating layers and clothing are then removed. The mass of the insulating layers and undergarments are then recorded.

e. The water ingress that occurred during the test is the difference between the post-test and pre-test mass of the insulating layers and undergarments plus the mass of any free water collected.

R.5.1.3 Following the 2 min of draining the exterior of the suit (see R.5.1.2), weigh each subject using the platform scale on which the 82 cm x 100 cm steel tray is positioned to catch dripping water. Record this weight minus the weight of the empty tray as the Ditching and Vital Actions Saturated Weight (DVASW).

R.5.1.4 Following the weighing (see R.5.1.3), with suit systems properly donned as per the manufacturer's instructions for travel configuration, have each subject slowly enter the UES with the UES instructor, ensure seals and closures remain out of the water.

R.5.1.5 Secure each test subject with a four-point harness in an aisle seat next to a trained diver/instructor who shall be seated next to the 46 cm x 55 cm window exit. The exit shall be in place for this test and cleared underwater by the diver/instructor. Each test subject shall follow the trained diver/instructor out the exit from the aisle seat and proceed to the surface. After being secured in the UES, the suit shall be established in the travel configuration. Upon hearing the instructor say “prepare to ditch” the test subject shall secure the suit system for water entry as per the manufacturer’s instructions. The instructor shall verify that the suit is sealed in accordance with the manufacturer’s instructions.

R.5.1.6 Following facility procedures and communications protocols, lower the UES such that the subject is completely submerged and inverted.

R.5.1.7 Upon commencing lowering of the UES, initiate the waves, wind and rain. Wind and waves shall be from the same direction (refer to figure R1).

R.5.1.8 Each subject shall exit the submerged inverted UES.

Note: Ensure that the UES position does not interfere with the wave.

R.5.1.9 Each subject shall swim upwind for at least 30 s, then inflate the buoyancy element, if fitted. The subject shall then swim downwind for at least 30 s to the life raft. If the raft is reached before the 30 s, the subject shall be instructed to hold on to the life raft Beckett line until signalled to start the next activity.

R.5.1.10 Each subject shall enter the life raft, at which point the wind, waves and rain shall be shut off. All subjects shall exit the life raft without re-entering the pool water.

R.5.1.11 Once on the pool deck the draining procedure described in R.5.1.2 shall be repeated.

R.5.1.12 After the 2 min period, weigh each subject using the platform scale on which the 82 cm x 100 cm steel tray is positioned to catch dripping water. Record this weight minus the weight of the empty tray as the Ditching and Vital Actions Water Ingress (DVAWI).

R.5.1.13 Conduct this test on all 12 subjects.

R.5.2 Procedure for water ingress for the survival phase immersion (SPI)

R.5.2.1 With suit systems properly donned, have each subject slowly enter the pool via a ladder in order to saturate the exterior of the suit. Ensure all seals remain out of the water. Using a warm water hose, spray any areas of the suit system not immersed in water. Continue this procedure for 3 min, and then have the subjects exit the water via the ladder.

R.5.2.2 Once on the pool deck, have the subjects perform the following steps:

R.5.2.2.1 Method one:

a. Where hand protection is not integral to the suit system, the subject shall remove the hand protection and hold inverted to drain excess water.

b. The subject shall stand for a period of 2 min to allow excess water to drain from the exterior of the suit system.

c. During this time the subject shall perform two series of forward and side bends and squats, holding each position for 10 s, to promote trapped water in the exterior of the suit to drain.

R.5.2.2.2 Method two: For some suit designs, the method described in R.5.1.2.1 is not effective. If necessary, the following method is also acceptable for measuring water:

a. Prior to the test, the mass of each layer of each suit is to be measured and recorded.

b. After the DVI test method, the subject exits the pool and the exterior of the suit is toweled dry.

c. When the exterior of the suit is sufficiently dryed so that the inner garments will not be contaminated with additional water, the suit can be removed. Any loose water contained within the suit is to be collected.

d. The watertight garment, insulating layers and clothing are then removed. The mass of the insulating layers and undergarments are then recorded.

e. The water ingress that occurred during the test is the difference between the post-test and pre-test mass of the insulating layers and undergarments plus the mass of any free water collected.

R.5.2.3 Following the 2 min of draining the exterior of the suit, weigh each subject using the platform scale on which the 82 cm x 100 cm steel tray is positioned to catch dripping water. Record this weight minus the weight of the empty tray as the Survival Phase Immersion Saturated Weight (SPISW).

R.5.2.4 Subjects shall enter the pool in groups that can be accommodated as per R.5.2.5. The subjects shall inflate the inflatable buoyancy elements, if fitted, and deploy the spray shields.

R.5.2.5 When all subjects are secured on the tether line, initiate waves, wind and rain. Wind and waves shall be from the same direction and perpendicular to the rope (see figure R1).

R.5.2.6 The wind, waves and rain shall continue for 30 min. When the wind, waves and rain are shut off, detached subjects from the surgical tubing and have them exit the pool via a ladder one at a time (subjects waiting in the pool shall ensure the suit system seals and closures remain out of the water).

R.5.2.7 Repeat the procedure in R.5.2.2 to allow the exterior of the suit system to drain prior to weighing.

R.5.2.8 Weigh each subject using the platform scale on which the 82 cm x 100 cm steel tray is positioned to catch dripping water. Record this weight minus the weight of the empty tray as the Survival Phase Immersion Water Ingress 30 minutes ($SPIWI_{30}$).

R.5.2.9 Repeat R.5.2.5 through R.5.2.9 with the same group of subjects for another 30-minute immersion and then record the weight minus the weight of the empty tray, as the Survival Phase Immersion Water Ingress 60 minutes ($SPIWI_{60}$). Repeat this process with groups of subjects until all 12 subjects have been tested.

Note: The following figure R1 is for guidance purposes only.

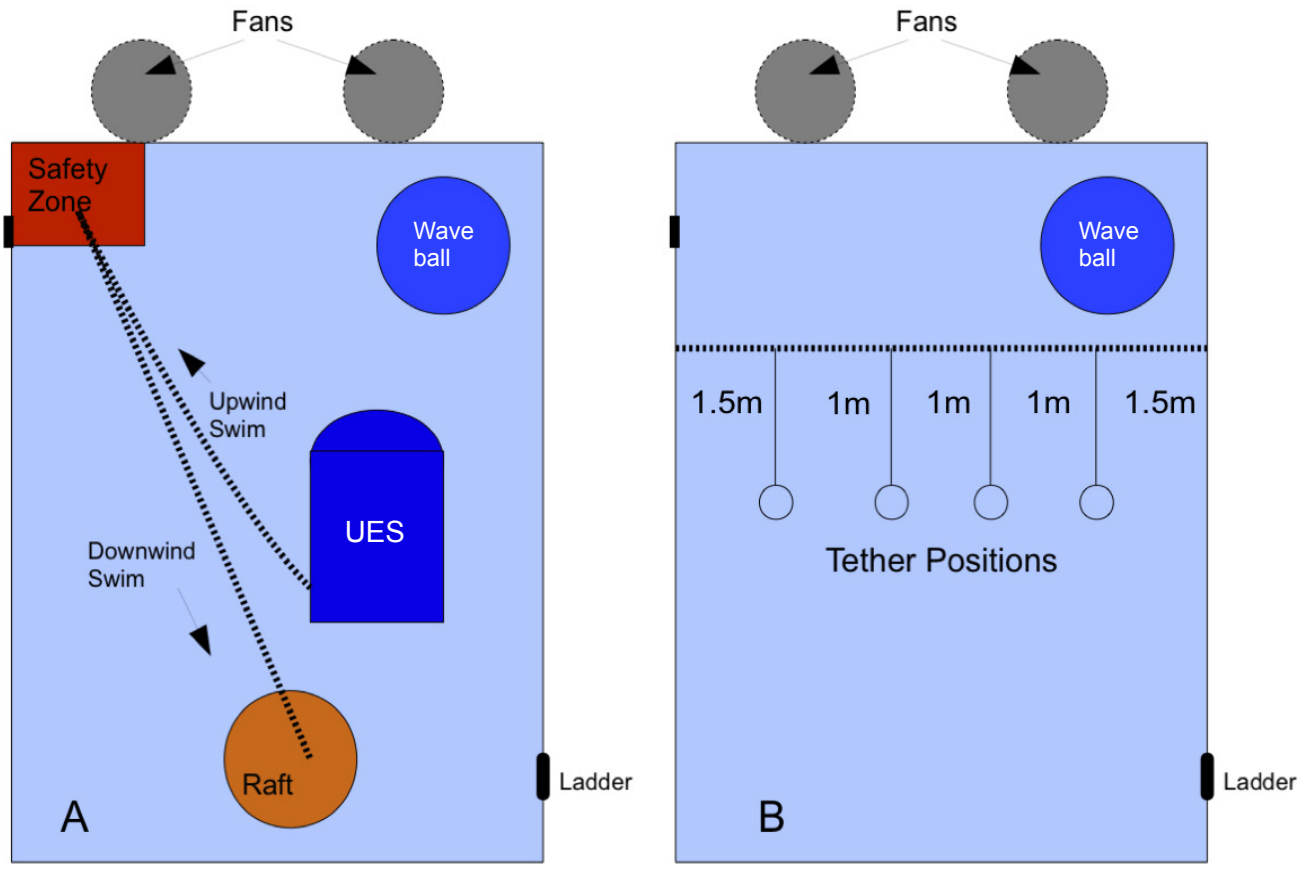

Figure R1
Equipment layout for water ingress tests (UES and survival phase immersion)

R.6 Calculation

Note: All measurements are in grams.

R.6.1 To calculate the DVAWI (ditching and vital actions water ingress) amount, take the mean DVASW for the 12 subjects and subtract it from the mean DVAWI for the 12 subjects.

R.6.2 To calculate the WI_{30} (water ingress amount for the first 30 min exposure), take the mean SPISW for the 12 subjects and subtract this from the mean $SPIWI_{30}$ for the 12 subjects.

R.6.3 To calculate the $SPIWI_{60}$, take the mean SPISW for the 12 subjects and subtract this from the mean $SPIWI_{60}$ for the 12 subjects to allow the slope of the line between 30 and 60 min values to be plotted to determine the WI rate.

R.6.4 To calculate the total water ingress amount in grams to be introduced during the thermal performance test described in Annex S, use the following formula:

$WI = (DVA + SD_d) + ((t-30)\ (WI\ rate) + (t/60)\ (SD_{60}) + (WI_{30}))$

where:

WI = Water ingress estimate

DVA = Ditching and Vital Actions

SD_d = 1 standard deviation from DVA

t = ½ of the desired prediction duration, in minutes

WI rate = slope of line between 30 and 60 min, in g/min

SD_{60} = 1 standard deviation of 60 min WI measurement

WI_{30} = 30-minute WI measurement.

Note: To calculate the standard deviation, first compute the difference between each subject's water ingress and the mean for the test and square the result of each. Then compute the average of these values, and take the square root.

Annex S
(normative)

Test method for thermal performance

S.1 Summary of method — Two methods are described for determining thermal performance, one using a thermal manikin, and the other using human subjects. The thermal manikin test method (see S.2) may only be used where the testing facility has established equivalency to the human test subject method (see S.3).

S.2 Thermal manikin

S.2.1 Summary of test method — The thermal insulation value of a suit system, expressed as m^2 K W^{-1}, is assessed by measuring the thermal resistance of the suit system and test clothing placed on a thermal manikin in turbulent conditions.

S.2.2 Sampling — One suit system sized to fit the thermal manikin.

S.2.3 Equipment — The following equipment is required:

a. A thermal manikin that the test house has established as providing results that are equivalent to human subjects in immersed tests. The surface area of the manikin shall be 1.8 m^2 ± 10%;

b. Frame for mounting the thermal manikin and lowering it into the water to achieve the freeboard position;

c. Wave tank;

d. Test clothing - See 7.7.

S.2.4 Preparation — The following conditions shall apply:

a. Minimum difference in temperature — The water temperature must be less than the thermal manikin surface temperature, as determined by the insulation provided by the suit system and the heating capacity of the manikin.

b. Conditions — Turbulent water condition.
Turbulent water conditions will be deemed to be acceptable when:
A thermal manikin (see S.2.3a) wearing test clothing and a 6.5 mm neoprene immersion suit (covering the entire body, excluding the face) in a natural flotation position (see S.2.5.1) is placed in turbulent water conditions that expose dorsal and ventral aspects of the suit to water flushing, the results shall approximate those provided in Annex J. This test must be completed with no water ingress.

S.2.5 Procedure

S.2.5.1 Freeboard — Using one test subject of the similar stature as the manikin wearing test clothing and the suit system donned and if fitted, the auxiliary buoyancy elements inflated, measure the freeboard to the mouth, abdomen and toes, perpendicular from the surface of the water as described in Annex L. The freeboard measurements shall be used for positioning the thermal manikin in the test.

S.2.5.2 Pre-weigh the test clothing including all items worn beneath the suit system and the suit system prior to dressing the thermal manikin.

S.2.5.3 Dress the manikin with the test clothing and suit system. Prior to closure of the suit system entry zipper, introduce the amount of water leakage as determined in Annex R. Distribute the water into those areas of the suit system where it had been earlier identified during the water ingress tests in Annex R.

S.2.5.4 After closing the entry zipper and ensuring that all other seals are fully closed and waterproofed, lower the thermal manikin into the water until the freeboard to the mouth, abdomen, and toe equals the amounts measured in S.2.5.1. This position may be achieved by using a frame on which the manikin is supported.

S.2.5.5 Measure and record the sectional temperatures of the thermal manikin and the water, and measure and record the power wattage used continuously. For each successive period not to exceed 15 min, record the mean values. Run the test until the manikin reaches a steady state.

S.2.5.6 Remove the thermal manikin from the water and re-weigh the test clothing including all items worn beneath the suit system. When removing the suit system ensure the undergarments are not contaminated by additional water during the undressing.

S.2.5.7 Determine whether any water ingress occurred into the suit system during the testing. If leakage occurred, repeat the test as necessary.

S.2.6 Calculation

S.2.6.1 The mean overall insulation is calculated by area weighting the insulation values for each section of the thermal manikin.

S.3 Human subjects

S.3.1 Summary of test method — The properties of a suit system can be evaluated by measuring the core body temperature change over time of human test subjects wearing a suit system.

S.3.2 Sampling

S.3.2.1 Subjects — Select a minimum of four males and four females including at least one subject from each of the six size categories specified in 7.1.1.

S.3.2.2 Suit systems — Select a suit system sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

S.3.3 Equipment — The following equipment is required:

a. monitor the test subjects core rectal temperature, skin temperature, skin heat flow, and heart rate;

b. thermistors or thermocouples and data collection system with an accuracy of 0.1 °C (see details in S.3.7);

c. Heat Flow Transducers (HFT's) (see details in S.3.7);

d. Heart rate monitor that uses an electrode-based chest strap transmitter;

e. Temperature controlled wave tank with wind capability.

S.3.4 Preparation — The following conditions shall apply:

a. Water — Conduct the test in water at a temperature between 0 °C and 2 °C.

b. Air temperature — Maintain the air temperature 300 mm above the water surface at less than 5 ± 1 °C.

c. Travelling waves with heights of 20-25 cm with a period between 1.8-2.2 s, and a wind between 20 and 25 km/h, travelling in the same directions as the waves shall be introduced in the vicinity of the test subject.

S.3.5 Medical assistance — A qualified EMT or physician shall be present during the entire test.

S.3.6 Termination criteria — If any of the following occurs, the test shall be terminated.

a. A 2 °C drop in deep body temperature from pre-immersion values

b. Completion of 6-hour duration

c. Physician/EMT determination that test subject should not continue

d. Test subject request (due to illness or discomfort)

e. Finger, toe or buttock temperature drop below 8 °C for more than 15 min and never below 5 °C.

S.3.7 Procedure

S.3.7.1 Record the test subject's anthropometric measurements (height, weight, and skinfold thickness), instruct about the use of a rectal temperature probe (the probe shall be inserted so the sensor (about 4 mm diameter) is 15 cm into the rectum). When the rectal probe[15] is inserted and the signal has been verified, the subject shall be prepared for instrumentation.

Each subject shall be instrumented with 13 heat flux/skin temperature (HFT) sensors[16] affixed to the skin using 3M Transpore surgical tape or equivalent product. The locations for the sensors are: forehead, R. (right) chest, R. abdomen, R. forearm, R. anterior thigh, R. shin, R. upper back, R. lower back, R. posterior thigh, R. calf, L. (left) posterior thigh, L. calf and R. buttock.

Any sensor locations with hair shall be shaved to ensure good contact with the skin. All sensor locations shall be prepared with Skin Prep (Smith & Nephew) or equivalent, prior to taping the HFT sensors to the skin to measure temperature and heat flow from the skin (T_{sk} and HF). Thermistors[17] are also affixed to the tip of the right index finger and right great toe.

S.3.7.2 Once instrumentation of the subject is complete, the subject shall don the test clothing and the suit system being tested. The test suit shall be instrumented on the exterior surface with thermistors at the same locations as the HFT sensors that are attached to the skin to measure suit temperature (T_{suit}). When the dressing is complete, the subject shall sit, and rest for 10 min for baseline data collection. To ensure the safety of the test subject, the subject shall be monitored in real time. Data shall be recorded on data loggers or an electrically isolated data acquisition system. In either case, rectal temperature (T_{re}) shall be monitored in real time during the test. Data should be averaged for every minute for each variable (T_{sk}, HF, and T_{re}).

S.3.7.3 When the baseline data collection period is complete, unzip the suits system and add the recorded water ingress amount determined in Annex R into the suit. Distribute the water into those areas of the suit system where it had been earlier identified during the water ingress tests. Once the water leakage has been introduced into the suit, the suit shall be closed and secured as ready for water entry. If fitted, the inflatable buoyancy element shall be inflated and the subject is then assisted into the water. Once they have entered the tank, the subject shall assume the natural flotation position and shall maintain the position in the water for the duration of the test. Tether the subjects during the immersion to maintain their position.

S.3.7.4 After 6 h of immersion, the subject shall exit the water, and the immersion suit, clothes, and sensors are removed. The subject shall then be aided in re-warming to a pre-test core body temperature (i.e. any measured core cooling has ceased and the core temperature is returning to the starting value). Repeat this procedure with each of the test subjects.

S.3.7.5 Record the change in T_{re} for each subject over the duration of the test.

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[15] Philips 400 series thermistor, model 21090A, Philips Medical Systems, or equivalent.

[16] Model FRM-060-TH44033, Concept Engineering, Old Saybrook, CT, or equivalent.

[17] Model H737 1.4 Kohm, Sensor Scientific Inc., Fairfield, NJ, U.S.A, or equivalent.

Annex T
(normative)

Test method for impact of jumping

T.1 Summary of method — The test method assesses the impact of jumping from a height of 4.5 m on the integrity of the suit system and its components, including the inflatable buoyancy element.

T.2 Sampling

T.2.1 Subjects — Select at least 12 test subjects for testing in accordance with 7.1.1.

T.2.2 Suit systems — Select a suit system sized for each subject tested. The sizing of the suit system shall be pursuant to the manufacturer's instructions.

T.3 Equipment — The following equipment is required:

a. A swimming pool of sufficient depth for jump entries from 4.5 m.

b. A jump platform.

T.4 Preparation — The following conditions shall apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

b. Subjects are instructed on proper jump technique prior to jump.

T.5 Procedure

Uninflated buoyancy element

T.5.1 Wearing test clothing and the suit system donned with the inflatable buoyancy element uninflated, if fitted, each subject shall jump feet first into the swimming pool from a minimum height of 4.5 m. Prior to each jump ensure no suit components are damaged.

T.5.2 Examine the suit system and the inflatable buoyancy element, if fitted, upon exit from the swimming pool for any damage. Record whether suit system components, including the inflatable buoyancy element, if fitted, are damaged or detached. Record any injuries to test subjects.

T.6 Procedure

Inflated buoyancy element

T.6.1 Wearing test clothing and the suit system donned with the inflatable buoyancy element inflated, if fitted, each subject shall jump feet first into the swimming pool from a minimum height of 4.5 m. Prior to each jump ensure no suit components are damaged.

T.6.2 Examine the suit system and the inflatable buoyancy element, if fitted, upon exit from the swimming pool for any damage. Record whether the suit system components, including the inflatable buoyancy element, if fitted, are damaged or detached. Record any injuries to test subjects.

Annex U
(normative)

Test method for temperature cycling

U.1 Summary of method — The following test method measures the integrity of the non-fabric non-metallic fittings used on the inflatable buoyancy element by determining if there is any damage or improper operation after being subjected to low and high temperature.

U.2 Sampling — Select five specimens of each non-metallic non-fabric fitting used on the inflatable buoyancy element for testing.

U.3 Equipment — The following equipment is required:

a. Temperature controlled chamber capable of 71 ± 2 °C;

b. Temperature controlled chamber capable of -51 ± 2 °C;

c. Temperature measuring device capable of measuring -51 ± 0.1 °C to 71 ± 0.1 °C;

d. Timing device.

U.4 Procedure

U.4.1 Subject each fitting to the following:

a. Maintain each fitting at -51 ± 2 °C for at least one hour in the cold temperature-controlled chamber or immerse in dry ice. If dry ice is used, place the fittings inside the dry ice and monitor the temperature next to each fitting with the temperature measuring device.

b. Remove each piece individually and test immediately upon removal so that the test is conducted at or as near as possible to -51 ± 2 °C.

c. Remove each fitting at the end of the period and operate it in the manner in which it was designed. Visually examine each fitting to determine if there is any change in physical characteristics.

d. Record any change in physical characteristics and whether the fittings failed to operate in the manner in which they were designed.

e. Then place the same fittings in the warm temperature controlled chamber maintained at 71 ± 2 °C for at least 1 h.

f. Remove each piece individually and test immediately upon removal so that the test is conducted at or as near as possible to 71 ± 2 °C.

g. Remove each fitting at the end of the period and operate it in the manner in which it was designed. Visually examine each to determine if there is any change in physical characteristics.

h. Record any change in physical characteristics and whether the fittings failed to operate in the manner in which they were designed.

Annex V
(normative)

Test method for oral inflation valve

V.1 Summary of method —The following test method measures the integrity of the oral inflation valve used on the inflatable buoyancy element. The specific method measures the opening pressure of the oral inflation valve, determines if there is any air leakage through the oral inflation valve and the oral inflation tube, and determines if there is any failure in the joints between the oral inflation valve and the oral inflation tube and between the oral inflation tube and the flotation chamber after application of a load.

V.2 Opening pressure

V.2.1 Sampling — Select nine samples of the oral inflation valve and the oral inflation tube for testing. The oral inflation tube is not to be bonded to the inflatable bladder fabric.

V.2.2 Equipment — The following equipment is required:

a. A source of compressed air;

b. A means of increasing pressure by a specific amount in a given period of time;

c. Hoses, fittings and clamps to attach the test samples to the compressed air source;

d. Timing device;

e. Air pressure gauge.

V.2.3 Conditioning — Condition three sets of three samples each as follows:

a. Place one set of three samples in a controlled environment at 23 ± 2 °C and 50 ± 5% RH for not less than 24 h.

b. Place one set of three samples in an atomized salt spray solution for a period of not less than 100 h in accordance with Annex E.

c. Subject one set of three samples in a controlled environment at −51 ± 2 °C for 24 h followed by an exposure to 71 ± 2 °C for 24 h.

V.2.4 Procedure

V.2.4.1 Attach the inlet side of the oral inflation valve to a source of pressure-controlled compressed air. Use an air pressure gauge to monitor the inlet side pressure.

V.2.4.2 Slowly increase the air pressure at a rate of 3.5 kPa/min.

V.2.4.3 Measure the opening pressure in kPa for each oral inflation valve with no backpressure applied.

V.2.4.4 Continue to test for leakage.

V.3 Leakage

V.3.1 Sampling — Use the three sets of specimens that were conditioned and tested in the opening pressure test (see V.2).

V.3.2 Equipment — The following equipment is required:

a. A source of compressed air;

b. A means of increasing pressure by a specific amount in a given period of time;

c. Hoses, fittings and clamps to attach the test specimens to the pressure source;

d. Tank of fresh water.

V.3.3 Procedure

V.3.3.1 Attach the outlet side of the oral inflation valve to a source of pressure-controlled compressed air. Use an air pressure gauge to monitor the outlet side pressure.

V.3.3.2 Slowly apply and increase the air pressure to the outlet side of each oral tube and valve assembly until a maximum air pressure of 69.0 kPa is reached.

V.3.3.3 Place the inlet side of each oral inflation valve below the surface of fresh water and visually observe for air leakage from any one of the valves.

V.3.3.3.1 If leakage occurs with any one of the three samples conditioned in the atomized salt solution spray, vigorously shake each sample in the fresh water for 15 s and repeat the test.

V.4 Joint integrity

V.4.1 Sampling — Select one sample of the oral inflation valve and the oral inflation tube that is attached in accordance with the manufacturer's attachment instructions to a piece of inflation chamber material.

V.4.2 Equipment — The following equipment is required:

a. Tensile testing machine;

b. Optional: Hoist and load of 445 N;

c. Timing device;

d. Adapter for supporting the point of attachment of the oral inflation tube to the fabric.

V.4.3 Procedure

V.4.3.1 Secure the ends of the oral inflation valve and tubing assembly between the jaws of a tensile testing machine. Optionally, use a hoist and dead load with appropriate clamps.

V.4.3.2 To support the inflation chamber material during load application, use an adapter having an inside diameter at least 19 mm larger than the outside diameter of the oral inflation valve at the point of attachment.

V.4.3.3 Optionally, using a hoist, apply a 445 N load for 3 s to the oral inflation valve such that it pulls outwardly from and perpendicular to the surface of the flotation chamber at the point of attachment.

V.4.3.4 Determine by visual inspection whether the joints between the oral inflation valve and the oral inflation tube and between the oral inflation tube and the flotation chamber failed.

Annex W
(normative)

Test method for mechanical inflation valve

W.1 Summary of method — The following test methods measure the integrity of the mechanical inflation valve used on the inflatable buoyancy element. The method measures air flow through the mechanical inflation valve, leakage through the mechanical inflation valve and determines if there is any failure in the joint between the mechanical inflation valve and the flotation chamber after the application of a load.

W.2 Air flow

W.2.1 Sampling — Select one specimen of the mechanical inflation valve for testing.

W.2.2 Equipment — The following equipment is required:

a. Compressed air source;

b. Means of controlling pressure;

c. Hoses, fittings and clamps to attach the test specimen to the pressure source;

d. Timing device;

e. Air pressure gauge;

f. Air flow gauge with the capacity of at least 100 L/min;

g. Temperature controlled chamber capable of temperature between -51 ± 2 °C and 71 ± 2 °C.

W.2.3 Conditioning — Condition the specimen as follows:

W.2.3.1 Subject the specimen to a temperature of -51 ± 2 °C for 24 h followed by an exposure to 71 ± 2 °C for 24 h.

W.2.4 Procedure

W.2.4.1 Attach the inlet side of the valve to a source of pressure-controlled air capable of providing a measure of pressure and the rate of air flow through the mechanical inflation valve assembly.

W.2.4.2 Apply an air pressure of 276 kPa to the inlet side of the valve.

W.2.4.3 Determine the airflow through the mechanical inflation valve in L/min.

W.2.4.4 Continue to test for leakage.

W.3 Leakage

W.3.1 Sampling — Use the specimen from the air flow test (see W.2) for testing.

W.3.2 Equipment — The following equipment is required:

a. Vacuum pump;

b. Two air pressure gauges;

c. Timing device;

d. Hoses, fittings and clamps to attach specimen to the pressure source.

W.3.3 Procedure

W.3.3.1 Attach the outlet side of the mechanical inflation valve to the vacuum pump. Use the air pressure gauges to monitor the pressures on each side of the valve.

W.3.3.2 Subject the mechanical inflation valve to a vacuum of 3 kPa (30.5 cm of water) on one side and atmospheric pressure on the opposite side. Orient the valve such that the application of vacuum reduces the seating spring pressure.

W.3.3.3 Measure and record the loss in pressure at the end of 1 min and 1 h in mm of water.

W.4 Joint integrity

W.4.1 Sampling — Select one specimen of the mechanical inflation valve that is attached to the inflatable bladder fabric in accordance with the manufacturer's attachment instructions for testing.

W.4.2 Equipment — The following equipment is required:

a. Tensile testing machine;

b. Optional: Hoist and load of 1112 N;

c. Timing device;

d. Temperature controlled chamber capable of temperatures between -51 ± 2 °C and 71 ± 2 °C;

e. Adapter for supporting point of attachment of mechanical inflation valve to the fabric, having an inside diameter of at least 19 mm larger than the outside diameter of the inflator at the point of attachment.

W.4.3 Conditioning — Subject the specimen to a temperature of -51 ± 2 °C for 24 h followed by an exposure to 71 ± 2 °C for 24 h.

W.4.4 Procedure

W.4.4.1 Secure the adaptor to the upper clamp and the mechanical inflation valve to the lower clamp of a tensile tester. Optionally, use a hoist and dead weight with appropriate clamps.

W.4.4.2 Optionally, using a hoist, apply a 1112 N load to the mechanical inflation valve such that it pulls outwardly from, and perpendicular to, the surface of the flotation chamber at the point of valve attachment for at least 3 s.

W.4.4.3 Determine by visual inspection and a leak test to the working pressure of the inflatable device whether the joint between the mechanical inflation valve and the flotation chamber material failed.

Annex X
(normative)

Test method for inflation mechanisms and gas cylinders

X.1 Summary of method — The following test methods measure the integrity of the inflation mechanism and gas cylinders. The specific method assesses whether the pull cord on the inflation mechanism is sufficiently strong for the application and whether the mechanism functions as intended when a measured force is applied to the pull cord. The method also assesses whether the inflation mechanism and gas cylinder properly resist damage when subjected to hydrostatic and air pressure.

X.2 Pull cord strength

X.2.1 Sampling — Select one specimen of the manual inflator mechanism and gas cylinder for testing.

X.2.2 Equipment — The following equipment is required:

a. Timing device;

b. Tensile testing machine;

c. Optional: Hoist and loads of 133 N and 267 N;

d. Temperature controlled chamber capable of temperatures between -51 ± 2 °C and 71 ± 2 °C.

X.2.3 Conditioning — Subject the specimen to a temperature of -51 ± 2 °C for 24 h followed by an exposure to 71 ± 2 °C for 24 h.

X.2.4 Procedure

X.2.4.1 Secure the inflation mechanism in the top clamp of the tensile tester and the end of the inflation mechanism's pull cord in the bottom clamp of the tensile tester. Optionally, use a hoist and dead load with appropriate clamps.

X.2.4.2 Apply a load of 267 N to the pull cord for at least 3 s.

X.2.4.2.1 If the pull cord is designed to separate from the inflation mechanism when operated, apply instead a load of 133 N for 3 s.

X.2.4.3 Determine whether the pull cord fails or separates from the inflation mechanism.

X.3 Inflator pull cord operating force

X.3.1 Sampling — Select three specimens of the manual inflator mechanism and gas cylinder for testing.

X.3.2 Equipment — The following equipment is required:

a. Timing device;

b. Constant rate extension tensile testing machine;

c. Temperature controlled chamber capable of temperatures between -51 ± 2 °C and 71 ± 2 °C.

X.3.3 Conditioning — Subject the specimens to a temperature of -51 ± 2 °C for 24 h followed by an exposure to 71 ± 2 °C for 24 h.

X.3.4 Procedure

X.3.4.1 Secure the inflator mechanism in the top clamp of the tensile tester, the end of the inflator lanyard in the bottom clamp of the tensile tester. Install a gas cylinder in the inflation mechanism.

X.3.4.2 Apply an increasing load at the rate of 30.5 cm/min to the pull cord until the pull cord actuates the cylinder and releases the gas contents.

X.3.4.3 Determine the maximum load in N required to activate the inflation mechanism, puncture the gas cylinder and release the gas contents.

X.4 Proof pressure

X.4.1 Sampling — Select one specimen of the inflation mechanism for testing.

X.4.2 Equipment — The following equipment is required:

a. Set screw;

b. Timing device;

c. Pressure gauge;

d. Tank;

e Fresh water;

f. Source of compressed air.

X.4.3 Conditioning — Subject the specimen to a temperature of -51 ± 2 °C for 24 h followed by exposure to 71 ± 2 °C for 24 h.

X.4.4 Procedure

X.4.4.1 Pressure (Hydrostatic)

X.4.4.1.1 Remove the valve core from the assembled inflator and replace it with a set screw and any necessary thread sealant required to block the passage of air.

X.4.4.1.2 With the lever arm in the closed position, apply a hydrostatic pressure of 10.34 MPa to the inflation mechanism for at least 30 s through the threaded opening for the gas cylinder.

X.4.4.1.2.1 Visually inspect the inflation mechanism to determine whether the inflation mechanism has deformed.

X.4.4.1.2.2 Repeat the testing of X.4.4.1.1 with the arm in the open position.

X.4.4.1.3 Continue to test for pressure (air) (see X.4.4.2).

X.4.4.2 Pressure (air)

X.4.4.2.1 Take the same specimen used for the pressure (hydrostatic) testing (see X.4.4.1).

X.4.4.2.2 Preparation

X.4.4.2.2.1 The following conditions apply:

a. Water — Conduct the test in calm fresh water at 23 ± 5 °C.

X.4.4.2.3 Place the inflation mechanism in a tank of fresh water. With the lever arm in the closed position, apply an air pressure of 13.8 kPa for 30 s through the threaded opening for the gas cylinder.

X.4.4.2.3.1 Visually inspect for any leakage of air from the inflation mechanism.

X.4.4.2.4 Repeat the test in X.4.4.2.3 with the arm in the open position.

X.4.4.2.5 Using the same sample, repeat X.4.4.2.3 with an air pressure of 275.8 kPa.

Annex Y
(normative)

Test method for flotation chambers

Y.1 Summary of method —This test method assesses the inflatable buoyancy element as to whether it inflates properly after exposure to a given range of operating temperatures, bursts upon activation of the inflation mechanism after oral inflation, bursts when over pressured, and leaks at lower operating pressures.

Y.2 Operating temperature

Y.2.1 Sampling — Select one specimen of the inflatable buoyancy element for testing.

Y.2.2 Equipment — The following equipment is required:

a. Compressed air source;

b. Temperature gauge;

c. Timing device;

d. Temperature-controlled chamber capable of temperatures between -40 ± 2 °C and 60 ± 2 °C;

e. Hearing protection, eye protection, preferably shielding between the test team and the device being tested.

Y.2.3 Conditioning — Subject each chamber of the specimen to a temperature of -40 ± 2 °C for 5 min followed by an exposure to 60 ± 2 °C for 5 min within the temperature-controlled chamber.

Y.2.4 Procedure

Y.2.4.1 Inflate each flotation chamber using the attached CO_2 cylinder first. Then release the pressure through the oral valve and then re-inflate through the oral valve with compressed air to 6.9 kPa.

Y.2.4.2 Determine whether the chamber inflated properly.

Y.3 Burst pressure

Y.3.1 Sampling — Use same sample as in Y.2. Install a new CO_2 cylinder.

Y.3.2 Equipment — The following equipment is required:

a. Air pressure gauge.

Y.3.3 Procedure

Y.3.3.1 Inflate each flotation chamber to an operating pressure of 6.9 kPa followed by a subsequent activation of the inflation mechanism.

Y.3.3.2 Determine whether the chambers burst.

Y.4 Over pressure

Y.4.1 Sampling — Select one specimen of the inflatable buoyancy element for testing.

Y.4.2 Equipment — The following equipment is required:

a. Source of dry compressed air;

b. Air pressure gauge;

c. Timing device.

Y.4.3 Procedure

Y.4.3.1 Inflate each flotation chamber to 69.0 kPa and maintain this pressure for at least 5 min.

Y.4.3.2 Determine whether the chambers burst.

Y.5 Leakage

Y.5.1 Sampling — Select one specimen of the inflatable buoyancy element for testing.

Y.5.2 Equipment — The following equipment is required:

a. Source of dry compressed air;

b. Barometric pressure gauge;

c. Timing device;

d. Hanging rack.

Y.5.3 Procedure

Y.5.3.1 Inflate each flotation chamber to 13.8 kPa using the compressed air and hang on a rack for at least 12 h.

Y.5.3.2 Using an air pressure gauge, the barometric pressure gauge and the temperature gauge, measure the pressure inside each flotation chamber, the external barometric pressure and temperature upon initial inflation.

Y.5.3.3 After 12 h, measure the pressure inside each flotation chamber, the external barometric pressure and temperature.

Y.5.4 Calculation

Y.5.4.1 Convert the initial final pressure inside each flotation chamber by applying the appropriate correction factors to account for fluctuation in the external barometric pressure and temperature.

Y.5.4.2 Determine the leakage in kPa of each chamber by calculating the difference in air pressure between the initial and final air pressure in each.

Y.5.4.3 Correct the flotation chamber pressure for temperature and ambient pressure as follows:

$$P_C = P_M \times \left(\frac{P}{101.3} \right) \times \left(\frac{293.2}{T_M} \right)$$

where:

P_C = corrected pressure, in kilopascals

P_M = measured final pressure, in kilopascals

P = atmospheric pressure, in kilopascals

T_M = temperature, in kelvins.