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WITHDRAWN

Helicopter Passenger Transportation Suit Systems

ICS 13.340.10

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NATIONAL STANDARD OF CANADA **CAN/CGSB-65.17-2012**

Supersedes CAN/CGSB-65.17-99

HELICOPTER PASSENGER TRANSPORTATION SUIT SYSTEMS

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

Prepared by the
Canadian General Standards Board CGSB

Approved by the
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FOREWORD

The primary objective of this standard is to provide performance requirements for a helicopter passenger transportation suit system. The 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.

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 Appendix 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] *Transport Canada, Airworthiness can be contacted at Standards Branch, AART, 330 Sparks Street, Transport Canada/Transports Canada, Place de Ville, Tower/Tour 'C' (AARTC) Ottawa, Ontario K1A 0N5.*

Supersedes CAN/CGSB-65.17-99

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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.

2. REFERENCED PUBLICATIONS

2.1 The following publications are referenced in this standard:

2.1.1 Canadian General Standards Board (CGSB)

CAN/CGSB-3.23-2012 — Aviation Turbine Fuel (Grades JET A and JET A-1)

CAN/CGSB-4.2 — Textile Test Methods:

No. 9.2-M90 (Reaffirmed 2004) — Breaking Strength of Fabrics — Grab Method — Constant–time-to-break Principle

No. 12.1-M90 (Reaffirmed 2004) — Tearing Strength — Single–Rip Method

No. 26.1-M88 (Reaffirmed 2001) — Water Resistance — Static Head Penetration Test

No. 32.2-M89 (Extended 1997) — Breaking Strength of Seams in Woven Fabrics.

2.1.2 ASTM International

D1434 — Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting

D1655 — Standard Specification for Aviation Turbine Fuels

D2061 — Standard Test Methods for Strength Tests for Zippers

D2062 — Standard Test Methods for Operability of Zippers

D2099 — Standard Test Method for Dynamic Water Resistance of Shoe Upper Leather by the Maeser Water Penetration Tester

D3886 — Standard Test Method for Abrasion Resistance of Textile Fabrics (Inflated Diaphragm Apparatus)

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

2.1.3 Federal Test Methods Standards (FTMS)

FTMS 191 A Method 5100.1 — Strength and Elongation, Breaking of Woven Cloth (Grab Method)

FTMS 191 A Method 5850 — Accelerated Aging of Cloth (Oven Method)

FTMS 191 A Method 5960 — Adhesion of Cemented Seams

FTMS 191 A Method 5970 — Adhesion Coating (Adhesive Method).

2.1.4 US Federal Aviation Administration (FAA)

TSO C85 — Survivor Locator Lights.

2.1.5 International Commission on Illumination (CIE)

CIE 015:2004 3rd Edition — Colorimetry.

2.1.6 International Organization for Standardization (ISO)

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

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

2.1.7 International Marine Organization (IMO)

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

2.1.8 UK Defence Standardization (DStan)

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

2.1.9 US Federal Aviation Regulations (FAR)

Part 25 — Airworthiness Standards: Transport Category Airplanes

2.10 US Department of Defence

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

2.11 Underwriter's Laboratory (UL)

ANSI/UL1191-2011 — Components for Personal Flotation Devices

UL 1197-2011 — Immersion Suits.

2.12 SAE International

SAE-AS6011 — Cylinders, Carbon Dioxide Filled, Technical

2.2 See Appendix A for applicable regulations.

2.3 A dated reference in this standard is to the issue specified. An undated reference in this standard is to the latest issue, unless otherwise specified by the authority applying this standard. The sources are given in the Notes section.

3. DEFINITIONS

The following definitions apply in this standard.

3.1 **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.*

3.2 **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.

3.3 **Buddy Line Receiving Point** — A ring, webbing loop or other 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.

3.4 **Clo** — The unit expressing the relative thermal insulation values of various clothing assemblies. One clo is equal to 0.155 $m^2 \cdot K \cdot W^{-1}$.

3.5 **Cold Shock** — The physiological response of organisms to sudden cold, especially cold water.

3.6 **Crew Member** —A person assigned to duty in an aircraft during flight time.

3.7 **Donning** — The complete securing of the suit system according to manufacturer's instructions.

3.8 **Escape Buoyancy** — The buoyancy of the suit system that must be overcome when escaping from an immersed inverted helicopter.

Note: *It 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*[2].

3.9 **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.

3.10 **Flotation Buoyancy** — The buoyancy available to the wearer from all elements of the suit system, including that of an inflated manually inflatable buoyancy element when fitted, but excluding entrapped air.

3.11 **Freeboard** — The perpendicular distances from the surface of the water to the corner of the mouth.

3.12 **Helicopter Underwater Escape Trainer (HUET)** —A 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 par. 7.8*

3.13 **Horizontal Righting** —The ability of a person to attain 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 **Inflatable Buoyancy Element** — A suit system component that provides an additional source of buoyancy to the suit system's inherent buoyancy.

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[2] *"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. As an "integral part" 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.*

3.16 **Inherent Buoyancy** — Buoyancy provided by a material, forming a permanent part of the suit, with a lower density than water.

3.17 **Passenger** —A person, other than a crew member, who is carried on board of an aircraft.

3.18 **Retro-Reflective Material** — A material that reflects light beams back to their points of origin.

3.19 **Righting** — For the purposes of this standard, it consists of horizontal righting (par. 3.13) and vertical righting (par. 3.28).

3.20 **Spray Shield** — A suit system component, which is a cover brought or placed in front of the face in order to reduce or eliminate the splashing of water onto the airways.

3.21 **Stability** — The ability of the suit system to maintain the person in a face-up position.

3.22 **Suit System** — A combination of a suit and any other components used in conjunction with it.

3.23 **Suit System Component** — A fitting that forms an integral or non-integral part of the suit system, or is attached to the suit.

3.24 **Survivor Locator Light** — A suit system component, which emits light used to locate the passenger at night or in low visibility conditions.

3.25 **Test Clothing** — Clothing wore under the suit system by the test subject and thermal manikin during the tests specified in this standard, unless the manufacturer specifies the clothing from skin out as part of the suit system.

***Note**: See also par. 7.7.*

3.26 **Thermal Manikin** — A model of a human figure with the surface area and shape similar to a 50th percentile male, which is made up of at least nine segments that can be individually heated to and controlled at a programmable uniform temperature at various points and that can be dressed in test clothing and the suit system.

***Note**: See also par. 7.9.*

3.27 **Vertical Positioning** — The ability of a person to attain and maintain a vertical position after swimming.

3.28 **Vertical Righting** — The ability of a person to attain a heads-up floating position upon entering the water headfirst.

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 attached. See par. 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 Where a measuring system is required by this standard, it shall have a valid calibration.

5. DETAILED REQUIREMENTS — SUIT SYSTEM

5.1 Seam Integrity

5.1.1 ***Breaking Strength*** — When tested in accordance with CAN/CGSB-4.2 No. 32.2-M89 (Extended 1997), the average breaking strength for each type of seam in the exterior fabric of the suit system shall be 300 N (par. 7.2.1).

5.1.2 ***Water Penetration*** — When tested in accordance with ASTM D2099, each seam in the exterior fabric of the suit system that needs to be watertight shall not exhibit any water penetration before 8000 cycles (par. 7.2.2).

5.2 Exterior Fabric Integrity

5.2.1 ***Breaking Strength*** — When tested in accordance with CAN/CGSB-4.2 No. 9.2-M90 (Reaffirmed 2004), the average breaking strength for the exterior fabric of the suit system shall be 300 N (par. 7.3.1).

5.2.2 ***Tearing Strength*** — When tested in accordance with CAN/CGSB-4.2 No. 12.1-M90 (Reaffirmed 2004), the average tearing strength for the exterior fabric of the suit system shall be 25 N (par. 7.3.2).

5.2.3 ***Abrasion Resistance*** — When tested in accordance with ASTM D3886, Option 1 *Failure,* no hole shall develop in the outer surface of each principal exterior fabric of the suit system following rubbing multi-directionally for at least 500 cycles (par. 7.3.3).

5.2.4 ***Water Penetration*** — When tested in accordance with ASTM D2099, the exterior fabric of the suit system shall not exhibit any water penetration before 10000 cycles (par. 7.3.4).

5.3 **Flame Exposure**

5.3.1 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.

5.3.2 When tested in accordance with ISO 15027-3, par. 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 (par. 7.4).

5.3.2.1 When tested in accordance with Appendix 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 Appendix 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 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 Appendix D, section D5),

b. 60 N following temperature conditioning when tested in accordance with ASTM D2062 (See Appendix D, section D5),

c. 175 N following salt spray conditioning when tested in accordance with ASTM D2062 (See Appendix D, section D5), and

d. 175 N following kerosene-type fuel conditioning when tested in accordance with ASTM D2062 (See Appendix D, section D5).

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 Appendix D, section D7.

5.5.3 ***Diagonal Pull*** — When tested in accordance with Appendix D, section D6, the zipper points for each sample shall not pull free.

5.5.4 ***Leakage***

5.5.4.1 When tested in accordance with Appendix D, section D8, water leakage shall not exceed 20 g prior to kerosene-type fuel exposure.

5.5.4.2 When tested in accordance with Appendix D, section D8, 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 Appendix 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 (par. 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 250 cm^2 of retro-reflective material, excluding that around the forearms, shall be visible above the water line. Of this 250 cm^2 reflective material, at least 100 cm^2 shall be affixed to the hood. Test in accordance with Appendix 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 250 cm^2 of retro-reflective material continues to be visible above the water line at all times when tested in accordance with Appendix F[3].

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

[3] *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.*

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

5.9.2 The survivor locator light shall comply with TSO C85.

5.10 **Whistle**

5.10.1 The suit system shall be equipped with a whistle.

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

5.10.3 The whistle's stowed location shall be visible and accessible to the wearer as per requirements in par. 5.20.3 and tested in accordance with Appendix P, section P6.

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 Appendix 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 Appendix P, section P6, the quick release shall function with one hand in accordance with the requirements of par. 5.20.3.

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

5.11.4 When tested in accordance with Appendix P section P6, 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 Appendix P section P6, the buddy line shall be positioned to be functional with one hand in accordance with the requirements of par. 5.20.3.

5.11.6 When tested in accordance with Appendix 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 Appendix 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 either incorporate or accommodate a boot or shoe with a hard sole.

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

5.13 **Spray Shield**

5.13.1 The suit system shall be equipped with a spray shield.

5.13.1.1 When tested in accordance with Appendix N, par. N7.3, the spray shield shall allow the wearers to see their surroundings.

5.13.2 When tested in accordance with Appendix P, section P6, 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 carrying out rescue action.

5.13.3 When tested in accordance with Appendix 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 Appendix 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 175N, when measured in accordance with Appendix K.

5.17 **Floating Characteristics**

5.17.1 ***Freeboard*** — When tested in accordance with Appendix L, section L5, the freeboard shall be at least 120 mm.

5.17.2 ***Stability*** — When tested in accordance with Appendix L, section L6, each subject shall assume a face-up 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 Appendix L, par. L7.1.

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 Appendix L, par. L7.2.

5.17.4 ***Vertical Positioning*** — When tested in accordance with Appendix M, each subject shall be able to assume 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 Appendix 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 Appendix 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 Appendix O, section O2, 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 Appendix O, section O3, 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 Appendix 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[4] and Seal Actions*** — When tested in accordance with Appendix P, section P4, 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.

5.20.2 ***Critical Survival Actions***

5.20.2.1 When tested in accordance with Appendix P, par. P5.1.1, where hand protection is worn[5] 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 Appendix P, par. P5.1.2, where the option exists to not wear hand protection in the helicopter[6], 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 Appendix P, par. P6.1.2, for the instance where hand protection is worn[7] 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 Appendix P, par. P6.1.3, for the instance where hand protection is removed[7] 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 Appendix Q, each subject shall exit the helicopter underwater escape trainer (HUET) unassisted and no component shall become fully dislodged or completely deployed.

5.22 **Thermal Performance in Water[8]**

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

5.22.2 ***Human Subjects and Thermal Manikin*** — Two methods of evaluating thermal performance of the suit system are provided. The manikin method may only be used where it has been established as equivalent to the human test method.

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

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

[5] *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.*

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

[7] *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.*

[8] *This standard bases thermal protection upon the following limits: no more than a* 2°C *core body temperature drop in 0-2 degree Celsius water over a 6- hour period and requires 0.75 immersed clo as tested in accordance with this standard.*

5.22.2.1 *Thermal Manikin* — When tested in accordance with Appendix S, the mean thermal insulation value provided by the suit system shall be at least 0.116 $m^2 \cdot K \cdot W^{-1}$ (0.75 immersed clo).

5.22.2.2 *Human Subjects* — When tested in accordance with section S3, the suit system shall provide thermal protection such that the average 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 Appendix T, the suit system and the suit system components, including the inflatable buoyancy element if fitted, shall not be damaged or detached.

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 that is not intended for removal by the wearer, or a separate detachable 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.

6.2 Coated Fabrics

6.2.1 ***Tensile Strength After Aging*** —After aging in accordance with FTMS 191 A Method 5850 (par. 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 (par. 7.6.2.1).

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

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

6.2.4 ***Gas Permeability*** — When tested in accordance with ASTM D1434, for the flotation chambers, the maximum permeability of the coated fabric to gas flow shall be 5 L/m^2 (par. 7.6.2.4).

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 of par. 6.3.

6.2.5.2 *Shear Strength After Aging* — After aging in accordance with FTMS 191 A Method 5850 (par. 7.6.1) and when tested in accordance with FTMS 191 A Method 5100.1, 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 (par. 7.6.3.1).

6.2.5.3 *Peel Strength After Aging* — After aging in accordance with FTMS 191 A Method 5850 (par. 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. (par. 7.6.3.2).

6.2.6 ***Heat-Sealed Seams***

6.2.6.1 *Sealing* — Heat-sealed seams, when used, may be sealed with a seam tape that meets the requirements of par. 6.3.

6.2.6.2 *Shear Strength After Aging* — After aging in accordance with FTMS 191 A Method 5850 (par. 7.6.1) and when tested in accordance with FTMS 191 A Method 5100.1, 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 (par. 7.6.4.1).

6.3 **Seam Tape**

6.3.1 ***Width*** — The seam tape used in cemented and heat-sealed seams shall be at least 30 mm wide.

6.3.2 ***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 (par. 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 (par. 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 (par. 7.6.7.1).

6.6 **Non-metallic non-fabric Items** — Upon temperature cycling and when tested in accordance with Appendix 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 par. 5.6.

6.8 **Rot** — Materials shall not support fungus growth.

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 Appendix P, section P6, 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 Appendix V, section V2, the opening pressure of each oral inflation valve shall not exceed 3.0 kPa.

6.9.2.2 *Leakage* — When tested in accordance with Appendix V, section V3, each oral inflation valve shall not leak.

6.9.2.3 *Joint Integrity* — When tested in accordance with Appendix V, section V4, 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 Appendix W, section W2, 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 Appendix W, section W3, 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 Appendix W, section W4, 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 gas for inflation purposes.

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.

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 Appendix X, section X2, 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 Appendix X, section X3, 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 Appendix X, section X4, 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 Appendix X, section X4, 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 Appendix P, section P6, 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 Appendix P, section P6, 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 Appendix Y, section Y2, each flotation chamber shall inflate by oral and mechanical inflation.

6.11.3 ***Burst Pressure*** — When tested in accordance with Appendix Y, section Y3, each flotation chamber shall not burst.

6.11.4 ***Over Pressure*** — When tested in accordance with Appendix Y, section Y4, each flotation chamber shall withstand an inflation pressure of at least 69.0 kPa.

6.11.5 ***Leakage*** — When tested in accordance with Appendix Y, section Y5, each flotation chamber shall not lose more than 3.5 kPa.

6.12 **Floating Characteristics** — See par. 5.17 for suit system requirements.

6.13 **Vertical Positioning** — See par. 5.17.4 for suit system requirements.

6.14 **Impact of Jumping —** When tested in accordance with Appendix 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 par. 5.15 for suit system requirements.

6.16 **Survivor Locator Light** — See par. 5.9 for suit system requirements.

6.17 **Colour of Suit System Exterior** — See par. 5.7 for suit system requirements.

6.18 **Flame Exposure** — See par. 5.3 for suit system requirements.

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[9]	< 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[10]	> 93.4	178.7	15

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 transportation suit systems.

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[9] *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.*

[10] *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.*

7.1.1.3 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 suit system components.

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 CAN/CGSB-4.2 No. 32.2-M89 (Extended 1997). Samples can be taken directly off suit system samples or samples shall be prepared separately using the same materials and construction methods.

7.2.2 ***Water Penetration*** — Test in accordance with ASTM D2099. Select one specimen of each seam type for testing.

7.3 **Exterior Fabric Integrity**

7.3.1 ***Breaking Strength*** — Test in accordance with CAN/CGSB-4.2 No. 9.2-M90 (Reaffirmed 2004).

7.3.2 ***Tearing Strength*** — Test in accordance with CAN/CGSB-4.2 No. 12.1-M90 (Reaffirmed 2004).

7.3.3 ***Abrasion Resistance*** — Test in accordance with ASTM D3886, Option 1. Test in a multi-direction until a hole formation has formed in the specimen. Select five exterior fabric specimens from each principal exterior fabric.

7.3.4 ***Water Penetration*** — Test in accordance with ASTM D2099. Select one exterior fabric specimen for testing.

7.4 **Flame Exposure** — Test in accordance with ISO 15027-3, par. 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 ageing, 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 par. 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 par. 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 par. 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 ASTM D1434. Perform the test using either helium or hydrogen gas at 25 ± 2°C, calibrating the permeameter for the gas used. Determine the average permeability of the coated fabric for a 24 h test period. Select three 125 x 125 mm specimens for testing.

7.6.3 ***Cemented Seams***

7.6.3.1 *Shear Strength After Aging* — Following the accelerated aging of samples in accordance with par. 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 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.

7.6.3.2 *Peel Strength After Aging* — Following the accelerated aging of samples in accordance with par. 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 **Helicopter Underwater Escape Trainer (HUET)**

7.8.1 The HUET 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. The HUET shall also be equipped with

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

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, and

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

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.

8. LABELLING

8.1 The suit system shall be labelled[11] with at least the following information:

Sizing information, including sizing range

Manufacturer's name

Date of manufacture of the suit system

Date of manufacture of the fabric

Model size

Lot number

Serial number

Standard Designation.

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.

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[11] *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 | Transports Canada Place de Ville, Tower | Tour 'C' (AARTC) Ottawa, Ontario K1A 0N5.*

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 prescribed 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

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

12. NOTES

12.1 **Sources of Referenced Publications**

The following addresses were valid at the date of publication.

12.1.1 The publications referred to in par. 2.1.1 may be obtained from the Canadian General Standards Board, Sales Centre, Gatineau, Canada K1A 1G6. Telephone 819-956-0425 or 1-800-665-2472. Fax 819-956-5644. E-mail at ncr.CGSB-ONGC@tpsgc-pwgsc.gc.ca. Web site www.tpsgc-pwgsc.gc.ca/ongc-cgsb.

12.1.2 The publications referred to in par. 2.1.2 may be obtained from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, U.S.A., Web site www.astm.org, or from IHS Canada, 1 Antares Drive, Suite 200, Ottawa, Ontario K2E 8C4, telephone 613-237-4250 or 1-800-267-8220, fax 613-237-4251. E-mail gic@ihscanada.ca. Web site http://global.ihs.com/.

12.1.3 The publication referred to in par. 2.1.3 and 2.1.6 may be obtained from IHS Canada, 1 Antares Drive, Suite 200, Ottawa, Ontario K2E 8C4, telephone 613-237-4250 or 1-800-267-8220, fax 613-237-4251. E-mail gic@ihscanada.ca. Web site http://global.ihs.com/.

12.1.4 The publication referred to in par. 2.1.4 and 2.1.9 may be obtained from the U.S. Department of Transportation-Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591. Telephone 1-866-835-5322. Web site: http://www.faa.gov/

12.1.5 The publication referred to in par. 2.1.5 may be obtained from Techstreet, 3916 Ranchero Dr. Ann Arbor, MI, USA 48108, telephone 1-800-699-9277, Email at techstreet.service@thomsonreuters.com, Web site http://www.techstreet.com/ or from the International Commission on Illumination, Web site http://www.cie.co.at/.

12.1.6 The publication referred to in par. 2.1.7 may be obtained from the International Marine Organization (IMO) Publishing Service, 4 Albert Embankment, London SE1 7SR, United Kingdom. Telephone +44 (0)20 7735 7611. Email at sales@imo.org. Web site www.imo.org

12.1.7 The publication referred to in par. 2.1.8 may be obtained from the UK Ministry of Defence - UK Defence Standardization (DStan), Kentigern House, Room 1138, 65 Brown Street, Glasgow G2 8EX. Telephone: 0141 224 2531. Email at enquiries@dstan.mod.uk. Web site http://www.mod.uk/DefenceInternet/AboutDefence/WhatWeDo/EquipmentandLogistics/dstan/

12.1.8 The publication referred to in par. 2.1.10 may be obtained from the US Department of Defense - Defense Standardization Program Office, 8725 John J. Kingman Rd, Stop 5100, Fort Belvoir VA 22060-6220. Telephone 215-697-6396. Email at http://www.dsp.dla.mil/APP_UIL/displayPage.aspx?action=content&contentid=66.

12.1.9 The publications referred to in par. 2.1.11 may be obtained from Underwriter's Laboratory (UL)-COMM 2000, 151 Eastern Avenue, Bensenville, IL 60106. Telephone 1-888-853-3503. Email at orders@comm-2000.com. Web site http://www.comm-2000.com/.

12.1.10 The publications referred to in par. 2.1.12 may be obtained from SAE International, SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA. Telephone 1-877-606-7323. Email at CustomerService@sae.org. Web site http://www.sae.org/standards/.

(This appendix does not form a mandatory part of the standard.)

FEDERAL AND PROVINCIAL ACTS AND REGULATIONS APPLICABLE TO HELICOPTER PASSENGER TRANSPORTATION SUIT SYSTEMS (par. 2.2) [A1, A2 and A3]

A1. 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.

A2. PROVINCIAL REGULATIONS

A2.1 Nova Scotia

Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act, Chapter 3 of the Acts of 1987 (including amendments)

Nova Scotia Offshore Area Petroleum Geophysical Operations Regulations, N.S. Reg. 191/95

A2.2 Newfoundland and Labrador

Canada-Newfoundland Atlantic Accord Implementation Act, S.C. 1987, c.3 (including amendments)

Newfoundland Offshore Area Petroleum Geophysical Operations Regulations, SOR/95-334

[A1] *The regulations listed are subject to revision by the relevant authority. The user should 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.*

[A2] *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.*

[A3] *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.*

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR WATER PENETRATION BEFORE AND AFTER FLAME EXPOSURE

B1. **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 par. 5.3.2.

B2. **SAMPLING**

B2.1 **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.

B3. **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.

B4. **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.

B5. **PROCEDURE**

B5.1 **Water Penetration Prior to Flame Exposure**

B5.1.1 The subject shall don the undergarments and the suit system and gently enter the swimming pool or tank.

B5.1.2 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.

B5.1.3 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.

B5.1.4 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.

B5.2 **Flame Exposure**

B5.2.1 Thoroughly dry the suit system and the undergarments used in par. B5.1 and subject it to the flame exposure required in par. 5.3.2.

B5.3 **Water Penetration Following Flame Exposure**

B5.3.1 The subject shall don dry undergarments and the suit system used in par. B5.2 and gently enter the swimming pool or tank

B5.3.2 Repeat the procedure in par. B5.1.2 and B5.1.3.

B5.3.3 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 par. B5.1.4 such that any wet areas are clearly visible in the photographs.

B6. **CALCULATION**

B6.1 Compare the wet areas in the photographs from par. B5.1.4 and B5.3.3. Calculate and record the difference between the wet areas in the photographs taken in par. B5.1.4 and B5.3.3.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR KEROSENE-TYPE FUEL EXPOSURE

C1. **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.

C2. **SAMPLING**

C2.1 **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 150mm 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 150mm x 150 mm

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

C3. **EQUIPMENT** — The following equipment is required:

a. Kerosene-type fuel meeting DEF STAN 91-91, ASTM D1655, or CAN/CGSB-3.23-2012

b. A container suitable to the purposes described below.

C4. **CONDITIONING**

C4.1 Immerse the specimens of exterior fabric and each type of seam from each of the suit system samples in kerosene-type fuel for a period of 6 h. After removal from the container, remove any surface fuel by wiping prior to proceeding.

C4.2 Examine the samples for cracking or swelling.

C5. **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).

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR ZIPPERS

D1. **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.

D2. **SAMPLING** — Select samples for testing as follows:

a. Eight zippers at least 750 mm long

b. Two zippers at least 305 mm long.

D3. **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 91-91, ASTM D1655, or CAN/CGSB-3.23-2012

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

g. A wood mounting board.

D4. **CONDITIONING**

D4.1 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% RH).

D4.2 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 Appendix 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).

D5. **OPENING AND CLOSING FORCE**

D5.1 **Procedure**

D5.1.1 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.

D5.1.2 Proceed to determine the diagonal pull force.

D6. DIAGONAL PULL

D6.1 **Preparation** — Open and mount onto a hard 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.

D6.2 **Procedure**

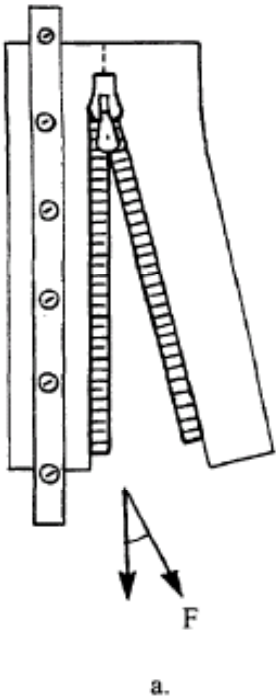
D6.2.1 Proceed as follows:

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.).

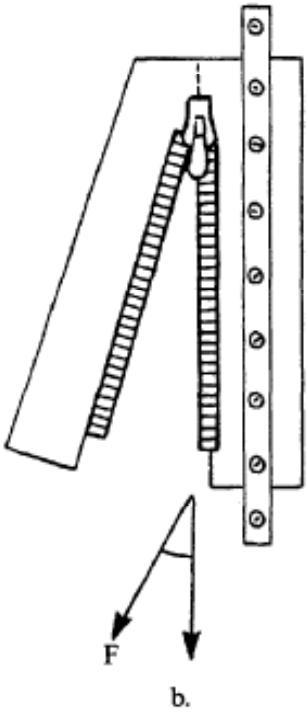
D6.2.2 When closed, pull the unsecured part of each zipper at an angle of 90° to the line of the zipper away from the secured part with a force of not less than 45 N (Figure D2). Determine whether the zipper sealing surfaces for each zipper pull free.

D6.2.3 Proceed to determine the crosswise strength.



a.

Figure D1 a.



b.

Figure D1 b.

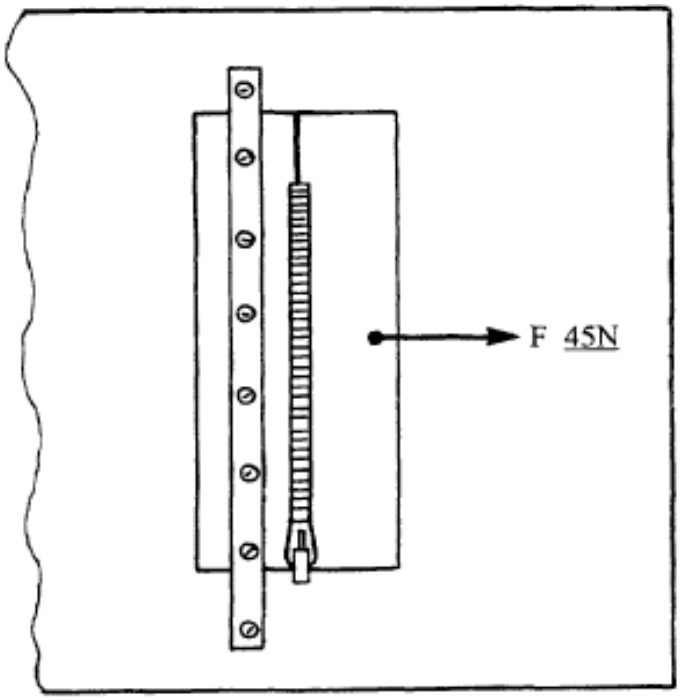


Figure D2

D7. CROSSWISE STRENGTH

D7.1 **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.

D7.2 **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 par. D4.2 d.

D8. LEAKAGE

D8.1 **Preparation**

D8.1.1 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.

D8.1.2 The following condition shall apply:

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

D8.2 **Procedure**

D8.2.1 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. Re-weigh 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.

D8.2.2 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 par. D8.2.1.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR CORROSION

E1. **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.

E2. **SAMPLING**

E2.1 **Specimens** — Select five specimens of each metal part for testing unless otherwise specified in the test methods included in this standard.

E3. **EQUIPMENT** — The following equipment is required:

a. A temperature controlled atomization chamber.

E4. **REAGENTS** — Sodium chloride (20% by weight) prepared from reagent grade sodium chloride (NaCl) containing no more than 0.2 % solid impurities.

E5. **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.

E6. **PROCEDURE**

E6.1 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.

E6.2 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.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR RETRO-REFLECTIVE MATERIAL[F1]

F1. **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.

F2. **SAMPLING**

F2.1 **Subjects —** Select at least 12 test subjects for testing in accordance with par. 7.1.1.

F2.2 **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.

F3. **EQUIPMENT —** The following equipment is required:

a. A swimming pool.

F4. **PREPARATION —** The following condition shall apply.

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

F5. **PROCEDURE**

F5.1 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 position.

F5.2 Measure the area of retro-reflective material visible above the water line. Measure the width of the retro-reflective material within each quadrant around each forearm.

F5.2.1 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.

F5.2.2 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.

F6. **CALCULATION —** Calculate the average area of retro-reflective material visible above the water line.

[F1] *This test may be carried out at the same time as that for Flotation Characteristics – Freeboard in Appendix J.*

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR BUDDY LINE

G1. **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 (par. 3.2) and buddy line receiving point (par. 3.3).

G2. **SAMPLING**

G2.2 **Suit Systems** — Select one suit system.

G3. **EQUIPMENT** — The following equipment is required:

a. Loads appropriate to test tolerances.

G4. **PROCEDURE**

G4.1 **Test the Buddy Line on the Suit System**

G4.1.1 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.*

G4.1.2 Observe and record any damage to the buddy line and any damage that could affect the function of the suit system.

G4.1.3 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.

G4.1.4 Observe and record at what force the buddy line parts or separate from the suit system and observe and record any damage that could affect the function of the suit system.

G4.2 **Test the Suit System's Buddy Line Receiving Point**

G4.2.1 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.*

G4.2.2 Observe and record any damage to the buddy line receiving point and any damage that could affect the function of the suit system.

G4.2.3 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.

G4.2.4 Observe and record at what force the buddy line receiving point parts or separate from the suit system and observe and record any damage that could affect the function of the suit system.

G4.3 **Test the Buddy Line Quick Release**

G4.3.1 Apply a test load equal to the force recorded in par. G4.1.4 to the buddy line quick release. Alternatively, apply a test load of 1500 N to the buddy line quick release.

***Note**: 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.*

G4.3.2 Manually function the buddy line quick release with one hand.

G4.3.3 Observe and record whether the buddy line quick release functions.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR FLOATING LIFE RAFT BOARDING

H1. **SUMMARY OF METHOD —** This test method evaluates the suit system's impact on the ability of wearers to board a life raft.

H2. **SAMPLING**

H2.1 **Subjects —** Select at least 12 test subjects for testing in accordance with par. 7.1.1.

H2.2 **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.

H3. **EQUIPMENT —** The following equipment is required:

a. A swimming pool

b. A SOLAS approved 10 to 14 person life raft with a boarding ladder

c. a SOLAS approved lifejacket.

H4. **PREPARATION —** The following condition shall apply:

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

H5. **PROCEDURE**

H5.1 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.

H5.2 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 life 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.

H6. **CALCULATION**

H6.1 Record the number of subjects that pass and do not pass.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR SPRAY SHIELDS

I1. **SUMMARY OF METHOD —** This test method is intended to measure the carbon dioxide levels under the spray shield when the shield is deployed.

I2. **SAMPLING**

I2.1 **Test Subjects —** Select at least six test subjects for testing.

I2.2 **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.

I3. **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.

I4. **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.

I5. **PROCEDURE**

I5.1 Each subject shall enter the pool and assume a face-up floating position.

I5.2 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.

I6. **CALCULATION**

I6.1 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 min period.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR FLOTATION BUOYANCY

J1. **SUMMARY OF METHOD** —This test method is intended to calculate the minimum flotation buoyancy of the suit system.

J2. **SAMPLING**

J2.1 **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.

J3. **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.

J4. **PROCEDURE**

J4.1 Submerge the basket so that its top edge is 50 mm below the surface of the water. Record the mass of the submerged basket.

J4.2 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 par. J4.6 and J4.7. 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.

J4.3 Submerge the basket so that all samples are fully under water and tilt the basket 45° from the vertical for 5 min in each of four different directions to allow any additional entrapped air to escape.

J4.4 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

J4.5 If the suit system contains inherently buoyant materials that have been removed in par. J4.2, place this material into the basket and determine the buoyancy as above. Repeat this procedure for each different inherently buoyant material.

J4.6 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 section J5.

J5. CALCULATION

J5.1 **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 (par. J4.4) shall be used as the flotation buoyancy.

J5.2 **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 ith 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 (par. J4.2) 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 ith buoyant material as determined in UL1191-2011, Section 24.3.

For neoprene materials, Vi = 100 – Ei

Where Ei is the Buoyancy Loss Factor of the ith buoyant material as determined in UL1197-2011, Section 24.6.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR ESCAPE BUOYANCY

K1. **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 HUET (par. 7.8).

K2. SAMPLING

K2.1 **Subjects —** Select at least 12 test subjects for testing in accordance with par. 7.1.1.

K2.2 **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.

K3. **EQUIPMENT —** The following equipment is required:

a. A HUET (par. 7.8) with a 46 cm x 55 cm exit window

b. A HUET Buoyancy Chair — A waterproof measuring device mounted on the HUET floor, married 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.

K4. **PREPARATION —** The following conditions shall apply:

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

b. A qualified HUET instructor and a diver shall be present for each test.

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

K5. BUOYANCY OF SUBJECT WEARING SWIM SUIT IN UPRIGHT POSITION

K5.1 **Procedure**

K5.1.1 Each subject wearing only a bathing suit shall enter the HUET. The subject shall assume a sitting position in the buoyancy chair.

K5.1.2 The HUET shall then be submerged. The subject shall maintain the crash position until motion of the HUET has stopped. When the motion has stopped, hold the position for 5 s, counted by the instructor or the diver. The subject shall then exit the HUET.

K5.1.3 Measure and record the buoyancy of the subject by taking an average of the last 2 s of the 5 s count. Subtract the buoyancy of the shoes, helmet and any additional safety gear worn by the test subject. This represents (A) in the equation found in par. K7.1.

K6. BUOYANCY OF SUIT SYSTEM

K6.1 **Procedure**

K6.1.1 Test subject shall don the test clothing and suit system with the detachable components in a stowed position.

K6.1.2 The suit system shall be open to travel configuration[K1]. The subject shall enter the HUET from a dry location, assume a sitting position in the buoyancy chair and be secured with a 4 point harness. The subject shall secure the suit system in accordance with the manufacturer's instructions (HUET instructor shall ensure the suit system is secured as per instructions).

K6.1.3 The test subject shall ensure feet remain on the buoyancy chair plate. Once secured, 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.

K6.1.4 The HUET shall then be submerged and inverted to 180º. The subject shall maintain the crash position, feet on buoyancy plate, until motion of the HUET 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 HUET.

K6.1.5 Measure and record the buoyancy of the subject wearing the suit system by taking an average of the last 2 s of the 5 s count.

K6.1.6 Repeat par. K6.1.2 through K6.1.5 two more times. Calculate the average of the results. This represents (B) in the equation found in par. K7.1.

K7. CALCULATION

K7.1 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 swim suit (K5.1.3)

(B) is the buoyancy of the subjects wearing the suit system (K6.1.6).

[K1] *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".*

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR FLOATING CHARACTERISTICS: FREEBOARD, STABILITY, RIGHTING

L1. **SUMMARY OF METHOD** — This test method evaluates the floating position by measuring freeboard, stability and righting characteristics of the suit system.

L2. **SAMPLING**

L2.1 **Subjects** — Select at least 12 test subjects for testing in accordance with par. 7.1.1.

L2.2 **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.

L3. **EQUIPMENT** — The following equipment is required:

a. A swimming pool.

L4. **PREPARATION** — The following condition shall apply.

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

L5. **FREEBOARD**

L5.1 **Procedure**

L5.1.1 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.

L5.1.2 Measure the freeboard in millimetres for each subject.

L6. **STABILITY**

L6.1 **Procedure**

L6.1.1 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 arms at the sides.

L6.1.2 The tester shall grasp both of the test subject's shoulders and turn the subject to 90° in one direction, then release. Record if the subject spontaneously returns to a face-up position without self assistance or assistance from the tester.

L6.1.3 Repeat par. L6.1.2 in the opposite direction. Record if the subject spontaneously returns to a face-up position without self-assistance or assistance from the tester.

L7. **RIGHTING**

L7.1 **Horizontal Righting**

L7.1.1 ***Procedure***

L7.1.1.1 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 under their own power for an additional 5 s.

L7.1.1.2 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.

L7.1.1.3 Repeat the procedure with the inflatable buoyancy element inflated when the suit system is fitted with an inflatable buoyancy element.

L7.2 **Vertical Heads-Up Righting**

L7.2.1 ***Procedure***

L7.2.1.1 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 jump into the water head first with hands by their sides by leaning over the side of the pool from a height of 1 m above the water surface.

L7.2.1.2 Measure and record the time in seconds that it takes for each subject to attain a heads-up floating position.

L7.2.1.3 Repeat the procedure with the inflatable buoyancy element inflated when the suit system is fitted with an inflatable buoyancy element.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR FLOATING CHARACTERISTICS: VERTICAL POSITIONING

M1. **SUMMARY OF METHOD** — This test method evaluates the suit system's impact on the ability to obtain a vertical position by requiring test subjects achieve and maintain a vertical position for an established period of time.

M2. **SAMPLING**

M2.1 **Subjects** — Select at least 12 test subjects for testing in accordance with par. 7.1.1.

M2.2 **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.

M3. **EQUIPMENT** — The following equipment is required:

a. A swimming pool.

M4. **PREPARATION** — The following condition shall apply:

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

M5. **PROCEDURE**

M5.1 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 be required to assume a vertical position within 1 min of a pre-arranged start signal and to maintain a vertical position without assistance for a 2 min period.

M5.2 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. A subject fails if

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

b. the legs rise to the water surface following the start signal 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 following the start signal.

M6. **CALCULATION**

M6.1 Record the number of subjects that pass and do not pass.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR ANGLE OF VISION

N1. **SUMMARY OF METHOD** — This test method is intended to ensure that the suit system does not significantly impair the wearer's angle of vision.

N2. **SAMPLING**

N2.1 **Subjects** — Prequalify at least six test subjects for testing (ensure one from each category as per par. 7.1.1) in accordance with the procedures set out in section N5, *Pre-qualification of Test Subjects*.

N2.2 **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.

N3. **EQUIPMENT —** The following equipment is required:

a. A Bohemier Perimeter Scope or similar device (see figures N1 to N4): It has studs to stabilize the subject's head and a 20 mm plastic tube bent to a semi-circle 2 m in diameter. Marks are placed on the ring at 150 mm intervals using a selection of coloured tapes

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.

N4. **PREPARATION** — The following condition shall apply:

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

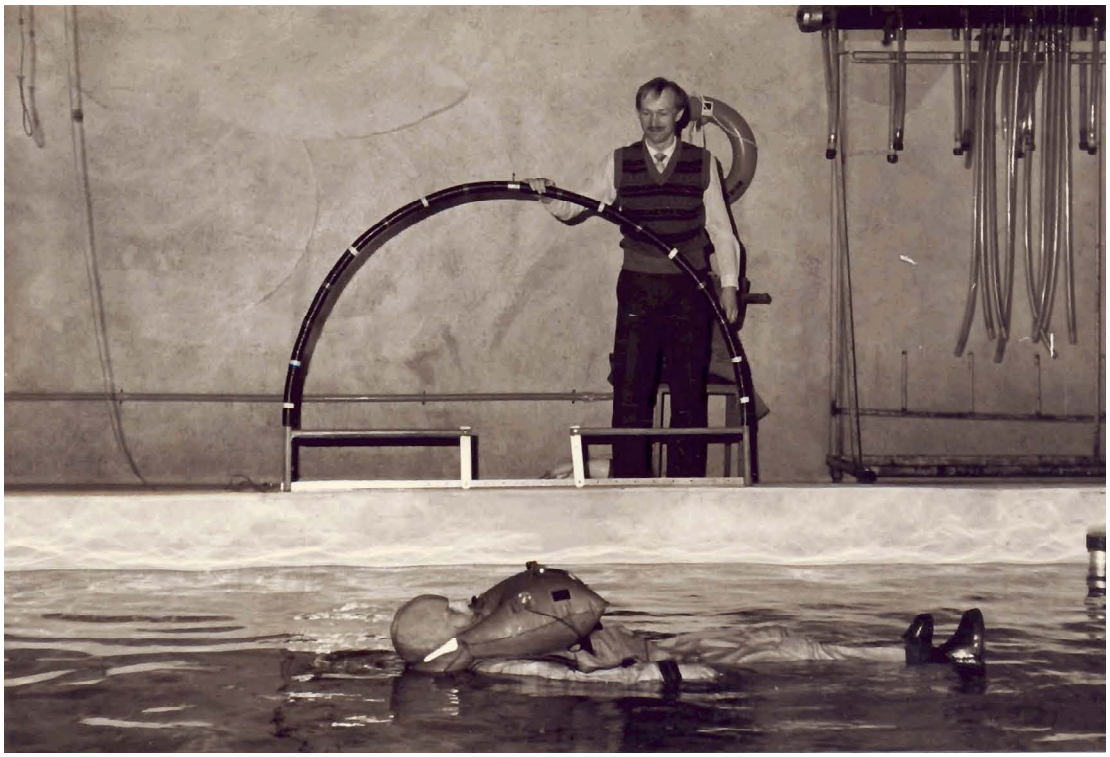


FIGURE N1
Bohemier Perimeter Scope

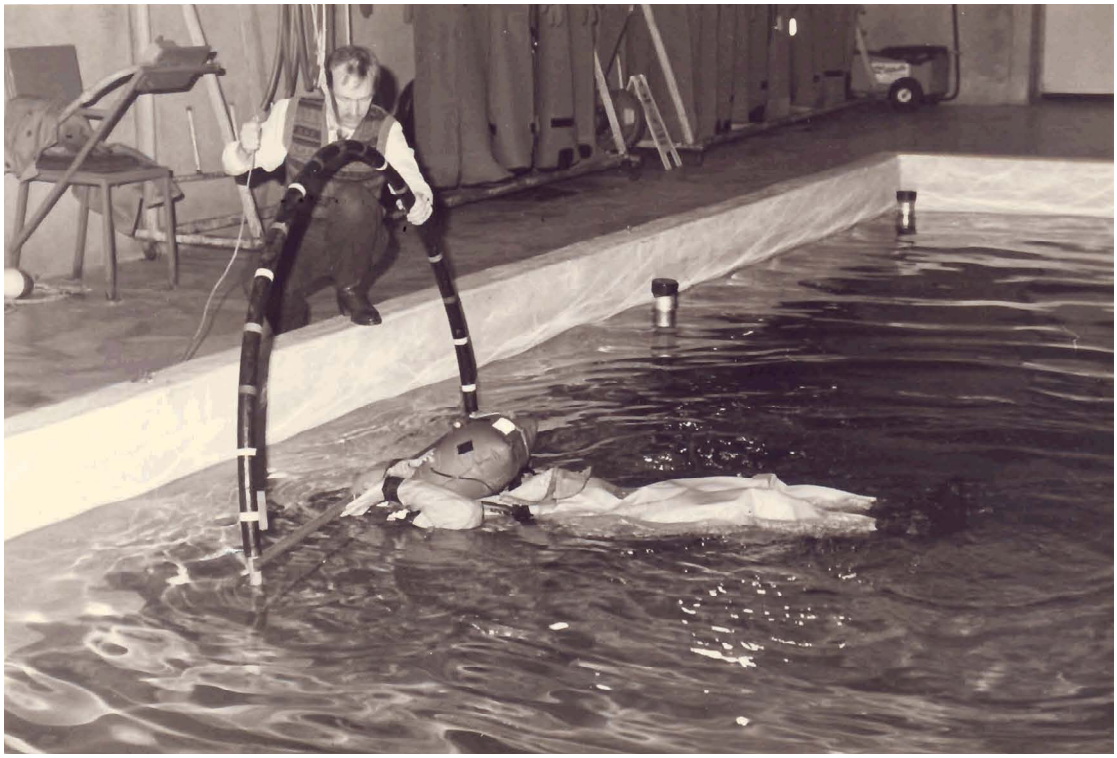


FIGURE N2
Bohemier Perimeter Scope — Lateral Plane

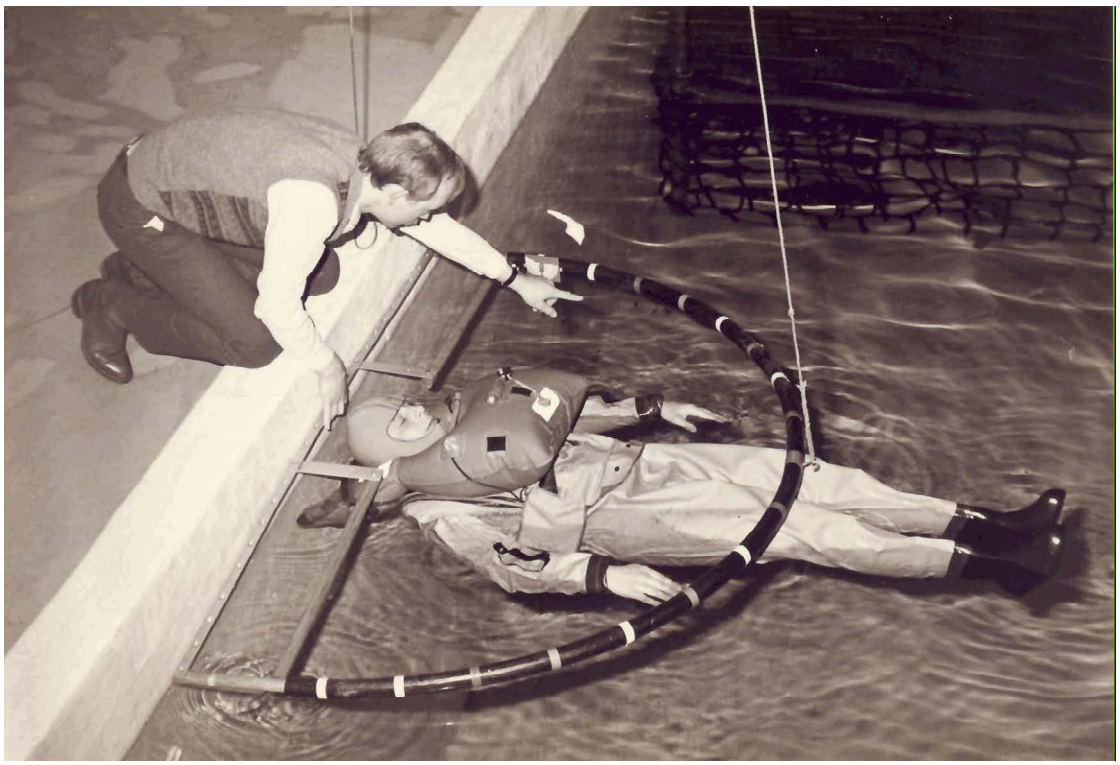


FIGURE N3
Bohemier Perimeter Scope — Horizontal Plane

FIGURE N4
Bohemier Perimeter Scope — Vertical Plane

N5. PRE-QUALIFICATION OF TEST SUBJECTS

N5.1 With each subject wearing only test clothing, seat each subject in a chair with their head perpendicular to the shoulder plane.

N5.2 With the subject's head forming the centre of a circle, move the cylinder or light source specified in section N3 c. around the test subject at eye level at a distance of 2 m. Instruct the test subjects that they shall only move their eyes.

N5.3 To qualify as a test subject, the subject shall be able to see the full 180º periphery.

N6. ANGLE OF VISION ON LAND

N6.1 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 section N5 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.

N6.2 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.

N7. ANGLE OF VISION IN THE WATER

N7.1 Each qualified subject, wearing test clothing and the suit system donned with the inflatable buoyancy element, if fitted, inflated, shall enter the pool and assume a relaxed position.

N7.2 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 fixed and eyes allowed to move.

N7.3 Deploy spray shield, verify that subjects can see their surroundings.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR MOBILITY

O1. **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.

O2. **CLIMBING**

O2.1 **Sampling**

O2.1.1 ***Subjects*** — Select at least 12 test subjects for testing in accordance with par. 7.1.1.

O2.1.2 ***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.

O2.2 **Equipment —** The following equipment is required:

a. A vertical ladder with rungs 300 mm apart

b. Athletic shoes sized to fit each subject.

O2.3 **Procedure**

O2.3.1 Each subject, wearing only the test clothing and athletic shoes, shall climb the vertical ladder until 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 back on the floor. Record the total time taken for the ascent and descent.

O2.3.2 Repeat par. O2.3.1 and calculate the average time for the two climbing tests.

O2.3.3 Following a minimum rest period of 5 min, each subject shall repeat the test in par. O2.3.1 wearing the test clothing and suit system donned in accordance with the manufacturer's instructions.

O2.3.4 Repeat par. O2.3.3 and calculate the average of the two climbing tests with the suit system donned.

O2.4 **Calculation —** Calculate the difference between the average time taken with the suit system donned and without the suit system donned expressed as a percentage.

O3. **WALKING**

O3.1 **Sampling**

O3.1.1 ***Subjects*** — Select at least 12 subjects for testing in accordance with par. 7.1.1.

O3.1.2 ***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.

O3.2 **Equipment —** The following equipment is required:

a. A smooth wet tile or painted concrete surface 120 m in length with at least four 90° turns, maintained at 23 ± 5°C.

b. Athletic shoes sized to fit each subject.

O3.3 **Procedure**

O3.3.1 Wearing only test clothing and the athletic shoes, each subject shall walk the 120 m distance and shall repeat the walk. Record the time taken for each walk.

O3.3.2 Following a rest period of at least 5 min, repeat par. O3.3.1 with each subject having donned the suit system following the manufacturer's instructions supplied with the suit system.

O3.4 **Calculation** — Calculate the difference between the average time taken with the suit system donned and without the suit system donned expressed as a percentage.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR SUIT SYSTEM COMPONENT DONNING AND USE

P1. **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.

P2. **SAMPLING**

P2.1 **Subjects —** Select at least 12 test subjects for testing in accordance with par. 7.1.1.

P2.2 **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.

P2.3 **Equipment —** The following equipment is required:

a. A swimming pool

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

P3. **PREPARATION —** The following condition shall apply:

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

P4. **HOOD AND SEAL ACTIONS**

P4.1 **Procedure**

P4.1.1 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. Proceed as follows:

a. Size and fit each subject to a helicopter 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 out of sight of any other subject 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[P1] as allowed for by the manufacturer's instructions.

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

P4.2 Record the time in seconds taken for each subject to complete the tasks in par. P4.1.1 g.

P5. **CRITICAL SURVIVAL ACTIONS**

P5.1 **Procedure**

P5.1.1 In the instance where the hand protection is worn in the helicopter, proceed to test as follows:

[P1] *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".*

a. Size and fit each subject to a helicopter 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. 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 out of sight of other subjects 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 the deployment mechanism and don 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[P2].

i. Record the time in minutes taken by each subject to complete all the tasks in par. P5.1.1 h.

P5.1.2 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 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 out of sight of other subjects 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 the deployment mechanism 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

[P2] *Including a second glove if it is a component of the suit system (as per manufacturer's instructions)*

iv. visually locate and don the hand protection.

h. Record the time in minutes taken by each subject to complete all the tasks in par. P5.1.2 g.

P5.1.3 Proceed immediately with the testing of rescue actions (section P6) while subjects are still in the water.

P6. RESCUE ACTIONS

P6.1 Procedure

P.6.1.1 Testing 'Rescue Actions' immediately follows the completion of 'Critical Actions' with subjects still in the water.

P6.1.2 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.

P6.1.2.1 Record the time in minutes required by each subject to complete all tasks.

P6.1.3 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 fall back to its deployed position

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.

P6.1.3.1 Record the time in minutes required by each subject to complete all tasks.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR UNDERWATER EGRESS FROM A HELICOPTER

Q1. **SUMMARY OF METHOD** — This test method assesses the performance of the suit system during egress from a helicopter underwater escape trainer (HUET). Consideration is given to the impact on mobility from buoyancy of the suit system and the dislodging of equipment from the suit system.

Q2. **SAMPLING**

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

Q2.2 **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.

Q3. **EQUIPMENT** — The following equipment is required:

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

b. A swimming pool.

Q4. **PREPARATION**

Q4.1 Each subject shall be trained in underwater egress. Training shall consist of a classroom briefing and a practice run, inverted in the HUET, conducted by a qualified HUET Instructor.[Q1]

Q4.2 Each subject shall become familiar with the test procedure prior to testing.

Q4.3 Conduct the test in calm fresh water at 23 ± 5°C.

Q4.4 Prior to each run, ensure all suit components are stowed in accordance with the manufacturer's instructions.

Q4.5 Each egress shall be video recorded from a location inside the HUET, the test subject's egress shall be clearly visible in the recording[Q2].

Q5. **PROCEDURE**

Q5.1 Secure the test subject with a four point harness in an aisle seat next to a trained diver/instructor who shall be seated next to the window exit.

Q5.2 A qualified HUET instructor shall observe the test from inside the HUET.

Q5.3 Lower the HUET such that the test subject is completely submerged and inverted 180° ± 10° (Figure Q3).

Q5.4 The test subject shall disengage the harness/seat belt and follow the trained diver/instructor out the exit from the aisle seat and proceed to the surface.

Q5.5 For each test subject repeat steps from par.Q5.1 to Q5.4 twice, once with the HUET inverted to 45° ± 10° and once inverted to 225° ± 10°. For each repetition, the test subject shall be seated on the same side of the HUET (Figures Q2 and Q4).

Q5.6 Record the number of instances where

a. any one of the test subjects requires assistance in any of their egresses, or

---

[Q1] *The test facility will ensure the instructor's qualifications are documented and available.*

[Q2] *Should the video recording fail, the run will be considered a pass if there is complete agreement between the observers.*

b. any component completely deploys or becomes fully dislodged any individual egress.

***Note**: Observations of the impact of buoyancy or component snagging should be captured for possible suit improvement opportunities.*

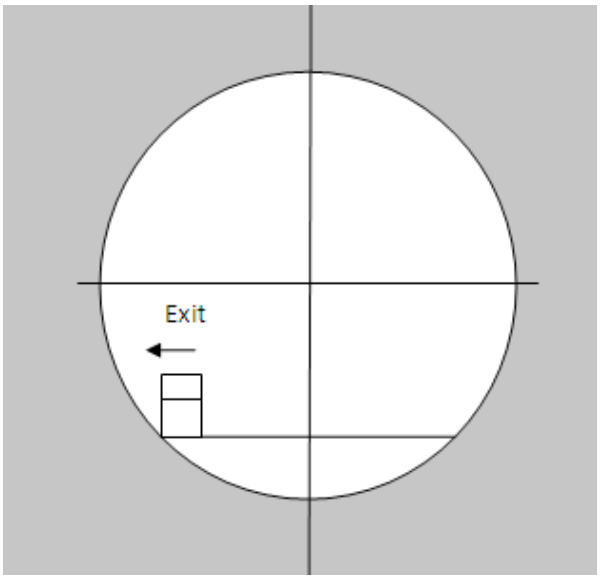


FIGURE Q1
Start Position

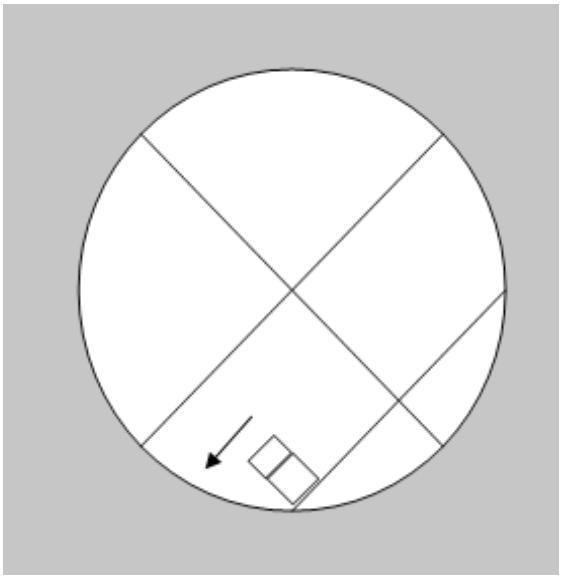


FIGURE Q2
45 Degree

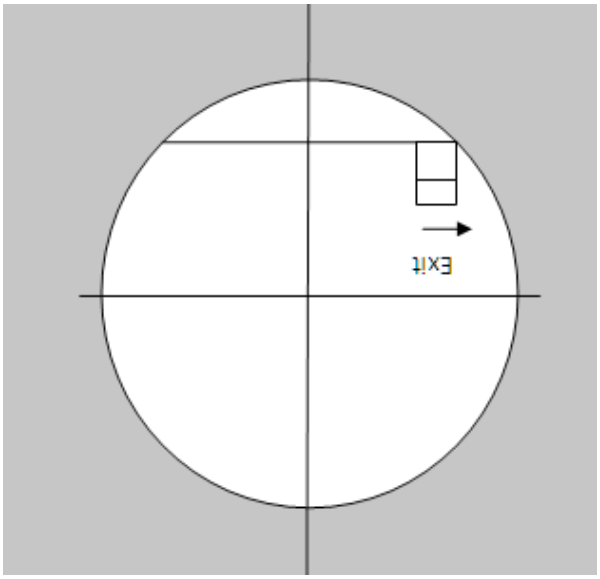


FIGURE Q3
180 Degree

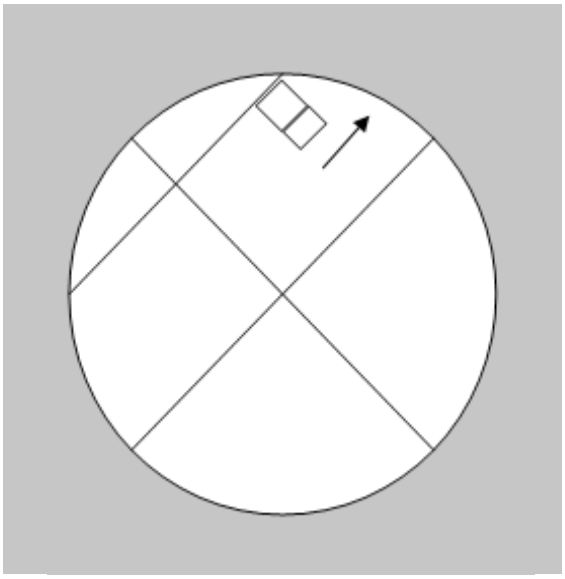


FIGURE Q4
225 Degree

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR WATER INGRESS

R1. **SUMMARY OF METHOD —** This test method determines the amount of water that enters the suit system following underwater egress from a HUET 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 HUET 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 Appendix S.

R2. **SAMPLING**

R2.1 **Subjects** — Select at least 12 human subjects for testing in accordance with par. 7.1.1.

R2.2 **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.

R3. **EQUIPMENT** — The following equipment is required:

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

b. A 82 cm x 100 cm steel 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

   ii. wave generator shall be capable of generating standing waves of 0.75 m

   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 nozzle used

d. A HUET (par. 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.

R4. **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 HUET instructor, rescue diver and hoist operator shall be present.

R4.1 Each subject shall be trained in underwater egress. Training shall consist of a classroom briefing and a practice run, inverted in the HUET, conducted by a qualified HUET instructor.

R4.2 Each subject shall become familiar with the test procedure prior to testing.

R5. **WATER INGRESS**

R5.1 **Procedure for Water Ingress for the Ditching and Vital Actions (DVI)**

R5.1.1 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.

R5.1.2 Once on the pool deck, have the subjects perform the following steps:

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.

R5.1.3 Following the 2 min of draining the exterior of the suit (par. R5.1.2), 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).

R5.1.4 Following the weighing (par. R5.1.3), with suit systems properly donned as per the manufacturer's instructions for travel configuration, have each subject slowly enter the HUET with the HUET instructor, ensure seals and closures remain out of the water.

R5.1.5 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. When entering and strapping into the HUET, the suit shall be worn as per the manufacturer's instructions for normal flight use (e.g. unzipped). 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.

R5.1.6 Lower the HUET such that the subject is completely submerged and inverted.

R5.1.7 Upon commencing lowering of the HUET, initiate the waves, wind and rain. Wind and waves shall be from the same direction (refer to Figure R1).

R5.1.8 Each subject shall exit the submerged inverted HUET.

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

R5.1.9 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 goal is achieved before the 30 s, the subject shall be instructed to wait until signalled to start the next activity.

R5.1.10 Each subject shall enter the life raft and wind, waves and rain shall be shut off. All subjects shall exit the life raft without having to re-enter the pool water.

R5.1.11 Once on the pool deck the draining procedure described in par. R5.1.2 shall be repeated.

R5.1.12 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).

R5.1.13 Conduct this test on all 12 subjects.

R5.2 **Procedure for Water Ingress for the Survival Phase Immersion (SPI)**

R5.2.1 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.

R5.2.2 Once on the pool deck, have the subjects perform the following steps:

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.

R5.2.3 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).

R5.2.4 Subjects shall enter the pool in groups that can be accommodated as per par. R5.2.5. The subjects shall inflate the inflatable buoyancy elements, if fitted, and deploy the spray shields.

R5.2.5 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 (Figure R1B).

R5.2.6 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 (Figure R1).

R5.2.7 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).

R5.2.8 Repeat the procedure in par. R5.2.2 to allow the exterior of the suit system to drain prior to weighing.

R5.2.9 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 ($SPIWI_{30}$).

R5.2.10 Repeat par. R5.2.5 through R5.2.9 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.*

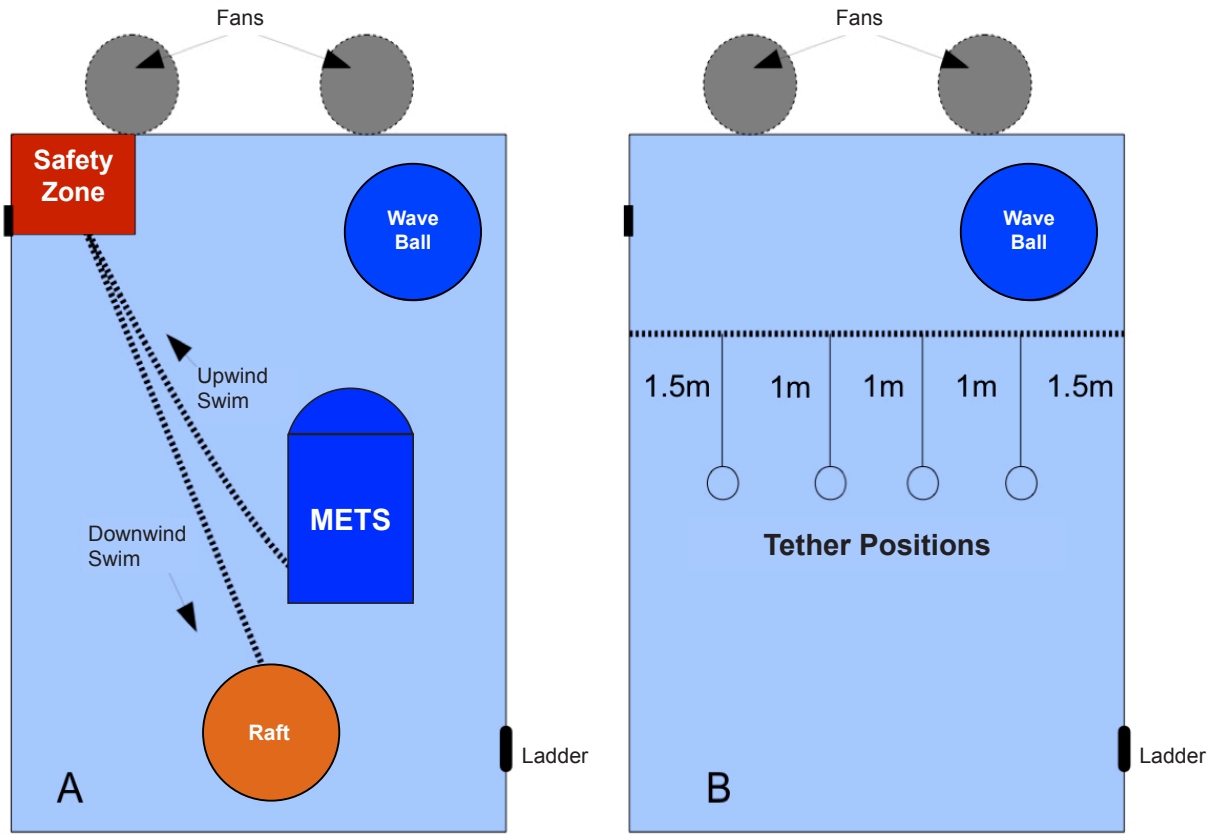


FIGURE R1
Equiptment Layout for Water Ingress Tests (HUET and Survival Phase Immersion)

R6. CALCULATION

Note*: All measurements are in grams.*

R6.1 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.

R6.2 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.

R6.3 To calculate the $SPIWI_{60}$ to allow the slope of the line between 30 and 60 min values to be plotted to determine the WI rate, take the mean SPISW for the 12 subjects and subtract this from the mean $SPIWI_{60}$ for the 12 subjects.

R6.4 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:

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

where:

WI = Water ingress estimate

DVA = Ditching and Vital Actions

SDd = 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.*

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR THERMAL PERFORMANCE

S1. **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 (section S2) may only be used where the testing facility has established equivalency to the human test subject method (section S3).

S2. THERMAL MANIKIN

S2.1 **Summary of Test Method** — The thermal insulation value of a suit system, expressed as $m^2 \cdot K \cdot W^{-1}$, is assessed by measuring the thermal resistance of the suit system and test clothing placed on a thermal manikin in turbulent conditions.

S2.2 **Sampling** — One suit system sized to fit the thermal manikin.

S2.3 **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.

S2.4 **Preparation** — The following conditions shall apply:

a. Minimum difference in temperature — The minimum temperature gradient shall not be less than 3°C between the thermal manikin and the water.

b. Conditions — Turbulent water with a wave height of 40 cm.

S2.5 **Procedure**

S2.5.1 ***Freeboard*** — Using one test subject of the same weight and height 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 Appendix L. The freeboard measured and body position shall be used for positioning the thermal manikin in the test.

S2.5.2 Pre-weigh the test clothing including all items worn beneath the suit system and the suit system prior to dressing the thermal manikin.

S2.5.3 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 Appendix R. Distribute the water into those areas of the suit system where it had been earlier identified during the water ingress tests in Appendix R.

S2.5.4 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 par. S2.5.1. This position may be achieved by using a frame on which the manikin is mounted.

S2.5.5 Set the target temperature of the thermal manikin at least 3º above the measured water temperature. 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.

S2.5.6 Remove the thermal manikin from the water and re-weigh the test clothing including all items worn beneath the suit system. Determine whether any water ingress occurred into the suit system during the testing. If leakage occurred, repeat the test as necessary.

S2.6 **Calculation**

S2.6.1 The mean overall insulation is calculated by area weighting the insulation values for each section of the thermal manikin.

S3. HUMAN SUBJECTS

S3.1 **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.

S3.2 **Sampling**

S3.2.1 **Subjects** — Select a minimum of four males and four females including at least one subject from each of the six size categories specified in par. 7.1.1.

S3.2.2 **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.

S3.3 **Equipment** — The following equipment is required:

a. An electrocardiograph (to monitor the test subjects, not as a measurement component of the test method)

b. Thermistor or thermocouple with an accuracy of 0.1°C

c. Temperature controlled wave tank with wind capability.

S3.4 **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.

S3.5 **Medical Assistance** — A qualified EMT or physician shall be present during the entire test.

S3.6 **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 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.

S3.7 **Procedure**

S3.7.1 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[S1] 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[S2] affixed to the skin using 3M Transpore surgical tape. The locations for the sensors are: forehead, R. (right). chest, R. abdomen, R. forearm,

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[S1] *Philips 400 series thermistor, model 21090A, Philips Medical Systems, or equivalent.*

[S2] *Model FRM-060-TH44033,Concept Engineering, Old Saybrook, CT, or equivalent.*

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) prior to taping the HFT sensors to the skin to measure temperature and heat flow from the skin (T_{sk} and HF). Thermistors[S3] are also affixed to the tip of the right index finger and right great toe.

S3.7.2 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[S3] 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. 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}).

S3.7.3 When the baseline data collection period is complete, unzip the suits system and add the recorded water ingress amount determined in Appendix 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.

S3.7.4 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.

S3.7.5 Record the change in T_{re} for each subject over the duration of the test.

[S3] *Model H737 1.4 Kohm, Sensor Scientific Inc., Fairfield, NJ, U.S.A, or equivalent.*

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR IMPACT OF JUMPING

T1. **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.

T2. **SAMPLING**

T2.1 **Subjects** — Select at least 12 test subjects for testing in accordance with par. 7.1.1.

T2.2 **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.

T3. **EQUIPMENT** — The following equipment is required:

a. A swimming pool

b. A jump platform.

T4. **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.

T5. **PROCEDURE**

T5.1 Wearing test clothing and the suit system donned with the inflatable buoyancy element, if fitted, uninflated, each subject shall jump feet first into the swimming pool from a minimum height of 4.5 m.

T5.2 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.

T5.3 Wearing test clothing and the suit system donned with the inflatable buoyancy element, if fitted, inflated, each subject shall jump feet first into the swimming pool from a minimum height of 4.5 m.

T5.4 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.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR TEMPERATURE CYCLING

U1. **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.

U2. **SAMPLING —** Select five specimens of each non-metallic non-fabric fitting used on the inflatable buoyancy element for testing.

U3. **EQUIPMENT —** The following equipment is required:

a. Temperature controlled chamber capable of 71°C

b. Temperature controlled chamber capable of -51°C

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

d. Optional: dry ice

e. Timing device.

U4. **PROCEDURE**

U4.1 Subject each fitting to the following:

a. Maintain each fitting at -51°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 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.

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

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

e. 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.

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

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR ORAL INFLATION VALVE

V1. **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.

V2. **OPENING PRESSURE**

V2.1 **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.

V2.2 **Equipment** — The following equipment is required:

a. A source of compressed air

b. A means of controlling pressure as a function of time

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

d. Timing device

e. Air pressure gauge.

V2.3 **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 Appendix 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.

V2.4 **Procedure**

V2.4.1 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.

V2.4.2 Slowly increase the air pressure at a rate of 3.5 kPa/min.

V2.4.3 Measure the opening pressure in kPa for each oral inflation valve with no backpressure applied.

V2.4.4 Continue to test for leakage.

V3. **LEAKAGE**

V3.1 **Sampling** — Use the three sets of specimens that were conditioned and tested in the opening pressure test (section V2).

V3.2 **Equipment** — The following equipment is required:

a. A source of compressed air

b. A means of controlling pressure as a function of time

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

d. Tank of fresh water.

V3.3 **Procedure**

V3.3.1 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.

V3.3.2 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.

V3.3.3 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.

V3.3.3.1 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.

V4. JOINT INTEGRITY

V4.1 **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.

V4.2 **Equipment** — The following equipment is required:

a. Tensile testing machine

b. Hoist and load of 445 N (optional)

c. Timing device

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

V4.3 **Procedure**

V4.3.1 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.

V4.3.2 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.

V4.3.3 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.

V4.3.4 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.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR MECHANICAL INFLATION VALVE

W1. **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.

W2. **AIR FLOW**

W2.1 **Sampling** — Select one specimen of the mechanical inflation valve for testing.

W2.2 **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 temperatures between -51 ± 2°C and 71 ± 2°C.

W2.3 **Conditioning** — Condition the specimen as follows:

W2.3.1 Subject the specimen to a temperature of -51 ± 2°C for 24 h followed by an exposure to 71 ± 2°C for 24 h.

W2.4 **Procedure**

W2.4.1 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.

W2.4.2 Apply an air pressure of 276 kPa to the inlet side of the valve.

W2.4.3 Determine the airflow through the mechanical inflation valve in L/min.

W2.4.4 Continue to test for leakage.

W3. **LEAKAGE**

W3.1 **Sampling** — Use the specimen from the Air Flow test (section W2) for testing.

W3.2 **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.

W3.3 **Procedure**

W3.3.1 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.

W3.3.2 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.

W3.3.3 Measure and record the loss in pressure at the end of 1 min and 1 h in mm of water.

W4. JOINT INTEGRITY

W4.1 **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.

W4.2 **Equipment** — The following equipment is required:

a. Tensile testing machine

b. Hoist and load of 1112 N (optional)

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.

W4.3 **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.

W4.4 **Procedure**

W4.4.1 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.

W4.4.2 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.

W4.4.3 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.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR INFLATION MECHANISMS AND GAS CYLINDERS

X1. **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 strong enough and whether the mechanism operates with the appropriate force 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.

X2. PULL CORD STRENGTH

X2.1 **Sampling** — Select one specimen of the manual inflator mechanism and gas cylinder for testing.

X2.2 **Equipment** — The following equipment is required:

a. Timing device

b. Tensile testing machine

c. Hoist and loads of 133 N and 267 N (optional)

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

e. Loads of 267 N and 133 N.

X2.3 **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.

X2.4 **Procedure**

X2.4.1 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.

X2.4.2 Apply a load of 267 N to the pull cord for at least 3 s.

X2.4.2.1 If the pull cord is designed to separate from the inflation mechanism when operated, apply instead a load of 133 N for 3 s.

X2.4.3 Determine whether the pull cord fails or separates from the inflation mechanism.

X3. INFLATOR PULL CORD OPERATING FORCE

X3.1 **Sampling** — Select three specimens of the manual inflator mechanism and gas cylinder for testing.

X3.2 **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.

X3.3 **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.

X3.4 **Procedure**

X3.4.1 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 and the gas cylinder to the inflation mechanism.

X3.4.2 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.

X3.4.3 Determine the maximum load in N required to activate the inflation mechanism, puncture the gas cylinder and release the gas contents.

X4. PROOF PRESSURE

X4.1 **Sampling** — Select one specimen of the inflation mechanism for testing.

X4.2 **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.

X4.3 **Conditioning** — Subject the specimen to a temperature of -51 ± 2°C for 24 h followed by exposure to 71 ± 2°C for 24 h.

X4.4 **Procedure**

X4.4.1 ***Pressure (Hydrostatic)***

X4.4.1.1 Remove the valve core from the assembled inflator and replace it with a set screw to block the passage of air.

X4.4.1.2 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.

X4.4.1.2.1 Visually inspect the inflation mechanism to determine whether the inflation mechanism has deformed.

X4.4.1.2.2 Repeat the testing of par. X4.4.1.2 with the arm in the open position.

X4.4.1.3 Continue to test for Pressure (Air) (par. X4.4.2).

X4.4.2 ***Pressure (Air)***

X4.4.2.1 Take the same specimen used for the Pressure (Hydrostatic) testing (par. X4.4.1).

X4.4.2.2 Preparation

X4.4.2.2.1 The following conditions apply:

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

X4.4.2.3 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.

X4.4.2.3.1 Visually inspect for any leakage of air from the inflation mechanism.

X4.4.2.4 Repeat the test in par. X4.4.2.3 with the arm in the open position.

X4.4.2.5 Using the same sample, repeat par. X4.4.2.3 with an air pressure of 275.8 kPa.

(This appendix forms a mandatory part of the standard.)

TEST METHOD FOR FLOTATION CHAMBERS

Y1. **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.

Y2. **OPERATING TEMPERATURE**

Y2.1 **Sampling** — Select one specimen of the inflatable buoyancy element for testing.

Y2.2 **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.

Y2.3 **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.

Y2.4 **Procedure**

Y2.4.1 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.

Y2.4.2 Determine whether the chamber inflated properly.

Y3. **BURST PRESSURE**

Y3.1 **Sampling** — Use same sample as in sectionY2. Install a new CO_2 cylinder.

Y3.2 **Equipment** — The following equipment is required:

a. Air pressure gauge.

Y3.3 **Procedure**

Y3.3.1 Inflate each flotation chamber to an operating pressure of 6.9 kPa followed by a subsequent activation of the inflation mechanism.

Y3.3.2 Determine whether the chambers burst.

Y4. **OVER PRESSURE**

Y4.1 **Sampling** — Select one specimen of the inflatable buoyancy element for testing.

Y4.2 **Equipment** — The following equipment is required:

a. Source of dry compressed air

b. Air pressure gauge

c. Timing device.

Y4.3 **Procedure**

Y4.3.1 Inflate each flotation chamber to 69.0 kPa and maintain this pressure for at least 5 min.

Y4.3.2 Determine whether the chambers burst.

Y5. LEAKAGE

Y5.1 **Sampling** — Select one specimen of the inflatable buoyancy element for testing.

Y5.2 **Equipment** — The following equipment is required:

a. Source of dry compressed air

b. Barometric pressure gauge

c. Timing device

d. Hanging rack.

Y5.3 **Procedure**

Y5.3.1 Inflate each flotation chamber to 13.8 kPa using the compressed air and hang on a rack for at least 12 h.

Y5.3.2 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.

Y5.3.3 After 12 h, measure the pressure inside each flotation chamber, the external barometric pressure and temperature.

Y5.4 **Calculation**

Y5.4.1 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.

Y5.4.2 Determine the leakage in kPa of each chamber by calculating the difference in air pressure between the initial and final air pressure in each.

Y5.4.3 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