JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 1191:2024

STANDARD FOR SAFETY

Components for Personal Flotation Devices

ANSI/UL 1191-2024

SCC FOREWORD

National Standard of Canada

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

UL Standard for Safety for Components for Personal Flotation Devices, ANSI/CAN/UL 1191

Fifth Edition, Dated May 28, 2019

Summary of Topics

This revision of ANSI/CAN/UL 1191 dated April 3, 2024 includes the following:

– Correction of Table 19.2 Webbing Closures and Adjusters

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated September 15, 2023 and February 23, 2024.

No Text on This Page

ANSI/UL 1191-2024

MAY 28, 2019
(Title Page Reprinted: April 3, 2024)

ANSI/CAN/UL 1191:2024

Standard for Components for Personal Flotation Devices

Previous numbered and unnumbered editions of standards covering components for personal flotation devices have been published since January, 1976.

First Edition – January, 1976
Second Edition – May, 1993
Third Edition – June, 1997
Fourth Edition – December, 2008

Fifth Edition

May 28, 2019

This ANSI/CAN/UL Safety Standard consists of the Fifth Edition including revisions through April 3, 2024.

The most recent designation of ANSI/UL 1191 as an American National Standard (ANSI) occurred on April 3, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on April 3, 2024.

No Text on This Page

CONTENTS

Preface 7

INTRODUCTION

1 Scope 11
2 General 11
2.1 Units of measurement 11
2.2 Use codes/product classifications 11
2.3 Material 12
2.4 Color – sample conditioning 12
2.5 Color – conspicuity 13
3 Definitions 15

THREAD

4 Construction 16
5 Performance 17
6 Marking 17

FABRIC

7 Construction 18
8 Performance 18
8.1 General 18
8.2 Yarn slippage – woven fabric only 18
8.3 Openness of weave 18
9 Marking 22

WEBBING AND TIE TAPE

10 Construction 22
11 Performance 22
11.1 General 22
11.2 Friction 22
11.3 Flexibility 22
11.4 Strength/slippage 23
11.5 Torsional stiffness 23
12 Marking 25

LACING

13 Construction 25
14 Performance 25
14.1 General 25
14.2 Untieability 26
15 Marking 26

ZIPPERS

16 Construction 27
17 Performance 27
17.1 General 27

17.2 Operability force test 29
17.3 Crosswise strength test 29
18 Marking 30

HARDWARE

19 Webbing Closures and Adjusters 30
19.1 General 30
19.2 Construction 31
19.3 Performance 31
19.4 Marking 33
20 Lacing Closures and Adjusters 34
20.1 General 34
20.2 Construction 34
20.3 Performance 34
20.4 Marking 37
21 Sailboard Harness Hooks 37
21.1 General 37
21.2 Performance 37
21.3 Marking 43
22 Multi-Eyelet Guides 43
22.1 General 43
22.2 Performance 43
22.3 Marking 44

FOAM FLOTATION MATERIAL

23 General 45
24 Performance 46
24.1 Density 46
24.2 Specific buoyancy 47
24.3 Buoyancy retention factors 48
24.4 Tensile strength 49
24.5 Oil resistance 50
24.6 Flexibility 51
24.7 Compression deflection 51
24.8 Dimensional analysis 51
24.9 Thickness 52
25 Marking 52

POLYMERIC ENCLOSURES FOR KAPOK

26 Performance 52
26.1 General 52
26.2 Air-leakage 53
26.3 Cold crack 55
27 Marking 58

RF WELDED, URETHANE COATED NYLON COMPARTMENT MATERIALS FOR HYBRID AND FULLY INFLATABLE RECREATIONAL PFDS

28 General 58
29 Performance 58
29.1 Breaking load test 58
29.2 Trapezoid tear strength test 61

29.3 Weight loss 62
30 Marking 62

INFLATION SYSTEMS FOR HYBRID AND FULLY INFLATABLE RECREATIONAL PFDS

31 Construction 62
31.1 General 62
31.2 Materials 63
31.3 Oral inflation systems 64
31.4 Actuation and rearming of manual, manual-auto, and automatic inflation systems 64
31.5 Means for verification of mechanism operation 65
31.6 Inflation medium and cylinders 65
31.7 Indicators 65
31.8 Window material 66
32 Performance 67
32.1 General 67
32.2 Use characteristics test – automatic, manual-auto, and manual inflation systems 68
32.3 Automatic operability test – automatic and manual-auto inflation systems 82
32.4 Conditioning test – cylinder seal indicating cylinders 83
32.5 Manual operability test – manual and manual-auto inflation systems 83
32.6 Operability test – oral systems 83
32.7 Discharge test – automatic, manual-auto, and manual inflation systems 83
32.8 Parallel and perpendicular strength of attachment – automatic, manual-auto, manual, oral inflation systems, and over-pressure relief valve systems 85
32.9 Humid atmosphere test – automatic and manual-auto inflation systems 85
32.10 System durability test – automatic, manual, and manual-auto inflation systems 88
32.11 Operability test – over-pressure relief valves 88
32.12 Pull test – automatic, manual-automatic and manual inflation systems, and cylinder seal indicating cylinders 88
32.13 Piercing test – cylinders 88
32.14 Inadvertent Puncture Test 95
32A Solid-State Circuitry Test – Electronic Inflation Systems 95
32B Battery Discharge Test – Electronic Inflation Systems 96
33 Marking 96

POLYMERIC COATINGS

34 Performance 97
34.1 General 97
34.2 Flexibility 98
34.3 Blocking 98
35 Marking 99

KNITTED FABRIC LAMINATED TO FOAM FLOTATION MATERIAL

36 Performance 100
36.1 Performance 100
36.2 Thermal insulation test 102
37 Marking 104

ANNEX A – NORMATIVE REFERENCES

ANNEX B (CAN) (NORMATIVE) MARKINGS – FRENCH TRANSLATION

No Text on This Page

Preface

This is the Fifth Edition of the ANSI/CAN/UL 1191, Standard for Components for Personal Flotation Devices.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 1191 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

Our Standards for Safety are copyrighted by ULSE Inc. Neither a printed nor electronic copy of a Standard should be altered in any way. All of our Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of ULSE Inc.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Personal Flotation Devices, TC 1123.

This list represents the TC 1123 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

TC 1123 MEMBERSHIP

Name	Representing	Interest Category	Region
Susan Balistreri	Balistreri Consulting Inc.	Producer	USA
David Broadbent	ABYC	Testing and Standards Org.	USA
Dennis Campbell	IMANNA Laboratory	Testing and Standards Org.	USA
Thomas Dardis	US Coast Guard	Government	USA
Jack Davis	Takashina Life Preservers Company, Ltd., DBA TLPC Japan	Producer	Japan
Brenda Espelien	PFD Consultants, Inc.	General Interest	USA
Troy Faletra	Custom Captains, Inc.	Producer	USA
John Fetterman	NASBLA	General Interest	USA
Sam Fowlkes	American Canoe Association	General Interest	USA

TC 1123 MEMBERSHIP Continued on Next Page

TC 1123 MEMBERSHIP Continued

Name	Representing	Interest Category	Region
Robin Holcomb	Sport Dimension, Inc., DBA Body Glove Wetsuit Co.	Producer	USA
Betty Holthouser	Standards Individuals	Consumer	USA
Ross Johnston	Industry Consultant Life Jackets & Survival Gear	Producer	Canada
Michael Kirkland	UL Solutions	Testing and Standards Org.	United Kingdom
Daniel Lanternari	Erez Thermoplastic Products	Supply Chain	Israel
Leon Larson	USA Water Ski	General Interest	USA
Allan Laursen	FORCE Certification A/S	Testing and Standards Org.	Denmark
Joshua Leblanc	West Jackson Fire Department	AHJ	USA
Emilie Letourneau	Transport Canada	Government	Canada
Robert Markle	Markle Marine Safety Services LLC	General Interest	USA
Guy Perrin	Sail Canada	Consumer	Canada
Paul Potter	The Cord Group Ltd	General Interest	Nova Scotia, Canada
Robert Rippy	The Coleman Company, Inc.	Producer	USA
Steve Rogier	Halkey-Roberts Corp	Producer	USA
Lee Stanford	Leland Ltd, Inc.	Producer	USA
Joseph Stimatz	Standards Individuals	Consumer	USA
Garfield Tam	Department of National Defence	Government	Canada
Doug Thomas	DSS Protection	Producer	Canada
Myles Uren	SPINLOCK	Producer	United Kingdom
Allen Van Camp	AJV. Inc.	Producer	USA
Wayne Walters	Kent Sporting Goods Co., Inc.	Producer	USA
Samuel Wehr	Standards Individuals	Consumer	USA
Jacqi Yurkovich	US Coast Guard	Government	USA
Milos Coric (TC Chair)	UL Standards & Engagement	Non-Voting	USA
Astrid Lozano	Public Works & Government Services Canada Standards Division	Non-Voting	Canada
Nicolette Weeks (TC Project Manager)	UL Standards & Engagement	Non-Voting	USA
Sharon White	US Consumer Product Safety Commission	Non-Voting	USA

International Classification for Standards (ICS): 13.340.70

For information on ULSE Standards, visit http://www.shopulstandards.com, call toll free 1-888-853-3503 or email us at ClientService@shopULStandards.com.

This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

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

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover components intended for use in the manufacturer of personal flotation devices and immersion suits. Compliance with these requirements does not indicate that the product is intended for use as a component of an end product without further investigation. The requirements shall be applied to other components if found to be appropriate.

1.2 The components addressed in this Standard are intended for use in personal flotation devices and immersion suits which comply with the requirements of Underwriters Laboratories Inc., the United States Coast Guard Subparts of Chapter I, Title 46, Code of Federal Regulations, and Transport Canada. These include:

a) USCG Subparts 160.002, 160.047, 160.048, 160.049, 160.050, 160.052, 160.053, 160.055, 160.060, 160.064, 160.076, 160.077, 160.150, 160.155, 160.171, and 160.176.

b) The requirements for:

1) Marine Buoyant Devices, UL 1123;

2) Buoyant Cushions, UL 1175;

3) Buoyant Vests, UL 1177;

4) Hybrid Personal Flotation Devices, UL 1517; and

5) Fully Inflatable Recreational Personal Flotation Devices, UL 1180.

6) Immersion Suits, UL 1197.

7) Personal Flotation Devices – Part 5: Buoyancy Aids (Level 50) – Safety Requirements, UL 12402-5.

1.3 These requirements also cover personal flotation device components intended to meet the requirements of the United States Coast Guard Subparts of Chapter I, Title 46, Code of Federal Regulations. These include USCG Subparts 164.019 and 164.023.

1.4 The components addressed in this Standard are not prohibited from being used on devices that comply with other regulations and requirements (other than those tabulated in 1.2) when the component meets the intent of the requirements of Underwriters Laboratories Inc., the United States Coast Guard, and Transport Canada.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Use codes/product classifications

2.2.1 One or more use codes shall be assigned to each device component to show the classification of PFD or immersion suit for which it is intended. See Table 2.1.

Table 2.1
Use codes

Use code	Product Classification	Description of device
1	Level 150 and 100 Lifejacket	Inherently Buoyant Adult or Child sizes
1F		Fully Inflatables
2	Level 100 Lifejacket	Recreational Buoyant Adult or Child sizes
2A		Recreational Buoyant Adult sizes only
2C		Recreational Buoyant Child sizes only
2F		Recreational Fully Inflatables
3F		Recreational Fully Inflatables
3	Level 50 and 70 Buoyancy Aid	Inherently Buoyant Adult or Child sizes
3A		Inherently Buoyant Adult sizes only
3C		Inherently Buoyant Child sizes only
3F		Inflatables
4	Throwable	Any Styles
4B		Any ring or horseshoe buoy
4BC		Buoyant Cushions
4H		Horseshoe buoys
4RB		Recreational ring buoys
5	Special Use Level 150 and 100 Lifejacket or Special Use Level 50 and 70 Buoyancy Aid	Any styles except Hybrids or work vests
5H		Hybrids
5SB		Recreational sailboard devices
5R		Any recreational style Type V; except Hybrids
5WV		Workvest
6F	Special Use Inflation systems	Unique, limited or restricted categories for devices not covered in this Table. When used, the intended application for this Use Code/Product Classification shall be specifically described, such as convertible inflation systems.
6I	Immersion Suit	Abandonment Suit or Constant Wear Suit

2.3 Material

2.3.1 Polymeric material shall comply with the regrind requirements specified in the Standard for Polymeric Materials – Fabricated Parts, UL 746D, and is to be determined the same when it is of the same generic type, the same kind and amount of resin, filler, stabilizers or reinforcement as demonstrated by the applicable identification tests.

2.4 Color – sample conditioning

2.4.1 When a textile or polymeric product is furnished in a range of colors, samples of each are to be provided for evaluation. Where various colors are evaluated by representative sample(s) of a range of colors, only the representative sample(s) are required to be evaluated.

Table 2.2
Sample conditioning

Exposure	Method
Standard Conditioning SC	Except for textile products (i.e., fabric, webbing, thread, tie tape), the applicable number of samples specified in each section are to be conditioned at 23 ±2°C (73 ±4°F) and 50 ±5 percent relative humidity for not less than 24 h prior to the tests. For textile products, the samples are to be conditioned at 21 ±2°C (70 ±4°F) and 65 ±5 percent relative humidity for not less than 24 h. A different temperature and relative humidity that provides equivalent conditioning is not prohibited from being used.
Natural Accelerated Weathering Nt_{75} Nt_{138}	Where Nt_{75} or Nt_{138} exposure is specified, samples are to be exposed to natural weathering of 75 or 138 MJ/m^2 of UV radiation below 385 nm, respectively in South Florida (approximately 3 or 6 months) beginning between May 21 and July 21. Unless otherwise specified specimens are to be mounted with the face side (the side normally exposed to sunlight in service) toward the light, open backing, 45° angle, facing south. Condition samples to Standard Conditioning after exposure.
Xenon Accelerated Weathering Xe_{500} Xe_{750} Xe_{1380}	Unless otherwise specified, specimens are to be mounted with the face side (the side normally exposed to sunlight in service) toward the light so that the exposed area of each specimen is perpendicular to the light source rays. Condition samples to Standard Conditions after exposure. Where Xe_{500} or Xe_{750} or Xe_{1380} exposure is specified, samples are to be exposed to 500 or 750 or 1380 KJ/ (m^2 · nm)[a,b,c]@ 340 nm of Xenon accelerated weathering conditions, respectively in accordance with the following specifications: Irradiance: 0.55 W/m^2 at 340 nm Filters: Daylight filters per ISO 4892-2 (if published, or substitute applicable ASTM) Black Panel Temp.: 63 ±2°C (145 ±4°F) Dry Bulb Temp.: 42 ±2°C (108 ±4°F) Relative Humidity (light only): 50% Initial Water Temp.[d]: 20 ±5°C (68 ±10°F) Test Cycle: 102 min of light / 18 min of light and water spray / 24 min dark and water spray

[a] 500 KJ/ (m^2 · nm) is approximately [0.55 W/(m^2 · nm)] · [3600 sec/hr · KJ/ 1000J] · [300 hr machine cycling · 83.3 percent light cycle]. Equivalent to 100 h of sunshine carbon arc accelerated weathering.

[b] 750 KJ/ (m^2 · nm) is approximately [0.55 W/(m^2 · nm)] · [3600 sec/hr · KJ/ 1000J] · [450 hr machine cycling · 83.3 percent light cycle]. Equivalent to 300 h of sunshine carbon arc accelerated weathering.

[c] 1380 KJ/ (m^2 · nm) is approximately [0.55 W/(m^2 · nm)] · [3600 sec/hr · KJ/ 1000J] · [835 hr machine cycling · 83.3 percent light cycle].

[d] Temperature of source water measured at inlet of test chamber.

2.5 Color – conspicuity

2.5.1 The color of the exposed portions of outer materials used on lifejackets, immersion suits, and their inflatable compartment materials, if applicable, (excluding components such as webbing, zips and other fittings) shall be in the color range from yellow to red; the chromaticity coordinates for non-fluorescent colors shall lie within one of the areas defined in Table 2.3 and the luminance factor shall exceed the corresponding minimum in Table 2.3. The chromaticity coordinates and the minimum luminance factor for fluorescent colors shall comply with Table 2.4.

Table 2.3
Chromaticity coordinates *x* and *y* and luminance factor *β* for yellow, orange and red non-fluorescent colors of lifejacket and immersion suit material

Color	Chromaticity coordinates		Luminance factor
	x	*y*	*β*
Yellow	0.389	0.610	> 0.35
	0.320	0.490	
	0.405	0.400	
	0.500	0.500	
Orange	0.500	0.500	> 0.25
	0.405	0.400	
	0.470	0.330	
	0.600	0.400	
Red	0.600	0.400	> 0.15
	0.470	0.330	
	0.525	0.270	
	0.700	0.300	

Table 2.4
Chromaticity coordinates *x* and *y* and luminance factor *β* for yellow, yellow-orange, orange and orange-red fluorescent colors of lifejacket and immersion suit material

Color	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	

2.5.2 The color of the material samples shall be measured with the procedures defined in CIE publication No. 15.2 with polychromatic illumination D65, 45/0 geometry and 2° standard observer. The specimen shall have a black underlay with reflectance of less than 0.,04. The specimens shall be conditioned for at least 24 h at (20 ±2)°C and (65 ±5)% relative humidity. If the CIE procedures are carried out in other than standard conditions described above, the test shall be conducted within 5 min after withdrawal from the conditioning atmosphere.

3 Definitions

3.1 For the purpose of this standard, the following definitions apply.

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

3.2.1 CRACK PRESSURE – Pressure at which the over pressure relief valves opens within an oral inflator.

3.3 CYLINDER SEAL INDICATOR – A visual display on an inflation system which provides information regarding the status of the seal on an installed cylinder.

3.4 DESIGN INFLATION RANGE – The range of buoyancy and pressure, as specified by the manufacturer, to which a compartment is capable of being inflated to provide the intended in-water performance.

3.5 FILLING (also referred to as Weft) – In woven fabrics, yarn running from selvage to selvage at right angles to the warp (for knitted fabric see Wale).

3.6 FILL RATIO – For inflation medium containers, the weight of the gas charge (in grams) divided by the volume of the inflation medium container (in milliliters).

3.7 FULL INFLATION – A chamber or chambers inflated to any value within the design inflation range.

3.8 INFLATABLE COMPARTMENT – A container that is inflated by a gas or other medium through an automatic, manual-auto, manual, or oral inflation system.

3.9 INFLATION SYSTEM – A means of inflating one or more compartments to make the device buoyant or more buoyant on demand, either actively or passively of the wearer's action, based on its type as follows:

a) AUTOMATIC INFLATION SYSTEM – A system that activates to inflate one or more compartments upon immersion in water without any action by the user (a passive system), and which has no provision for manually actuated inflation.

b) MANUAL-AUTO INFLATION SYSTEM – A system that activates to inflate one or more compartments upon immersion in water without any action by the user (a passive system), and which also has provision for being activated by a single deliberate user action, such as by the pulling of a lanyard.

c) MANUAL INFLATION SYSTEM – A system that inflates one or more compartments when activated by a single deliberate user action, such as by the pulling of a lanyard, and which has no provision for automatically actuated inflation.

d) ORAL INFLATION SYSTEM – A means for a user to blow air into a compartment by mouth.

e) MULTI-USE INFLATION SYSTEM – Either an automatic inflation system or manual-auto inflation system designed so that the inflation system can be used multiple times by means of rearming.

f) ONE-TIME USE INFLATION SYSTEM – Either an automatic inflation system or manual-auto inflation system, however designed so that the inflation system can be used only one time and must be completely replaced during rearming.

3.10 INITIAL JAW SEPARATION – The distance between the bottom of the top clamp and the top of the bottom clamp of a tensile test machine prior to testing.

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

3.11.1 LOW-VOLTAGE LIMITED ENERGY – A control circuit involving a peak open-circuit potential of not more than 24 volts (dc or peak) supplied by a primary battery or by an isolated secondary circuit, and where the current capacity is limited such that the allowable energy is not more than 100VA.

3.12 MULTI-POINT STATUS INDICATOR – A status indicator which utilizes two or more independent visual display points to communicate inflation system readiness.

3.13 SELVAGE – The uncut edge portion of a fabric.

3.14 SERVICEABILITY – The ease with which the inflation system mechanism is properly rearmed. Use Code 1F inflation systems have the most stringent serviceability requirements, with Use Code 2F and 3F systems having correspondingly less stringent requirements.

3.15 SERVICEABLE – Capable of continued use (i.e. exhibits no signs of functional deterioration, deformation of hardware, indicators not functional, oral inflation tube blocked or detached, and manual inflator trigger detached).

3.16 SINGLE-POINT STATUS INDICATOR – A status indicator which combines all system checks into a single visual display point to communicate inflation system readiness.

3.17 STATUS INDICATOR – The part or parts of an inflation system which provide user feedback to assist in keeping an inflatable PFD in an armed and ready condition. Use Code 1F inflation systems have the most stringent status indicator user recognition requirements, with Use Code 2F and 3F systems having correspondingly less stringent requirements.

3.18 WALE – In knitted fabrics, a column of loops in successive courses. The column is parallel to the loop axes.

3.19 WARP – In a woven fabric, the yarn running lengthwise, parallel to the selvage (for knitted fabrics see Course).

THREAD

4 Construction

4.1 Thread shall not contain cotton or be monofilament.

5 Performance

5.1 Thread shall comply with the requirements specified in Table 5.1 and United States Coast Guard Subpart 164.023 of Chapter 1, Title 46, Code of Federal Regulations – Thread for Personal Flotation Devices.

Table 5.1
Thread

Tests	Exposure[a]	Test methods	Number of samples[b]	Sample size[c] inch (mm)	Use Codes[d]	Compliance criteria pounds-force (N)
Single Strand Breaking Strength	**1.** SC **2a.** Xe_{500} **2b.** Xe_{750} or Nt_{750}	ASTM D204-93	5 for each separate exposure	36 (914)	1, 1F, 2, 2F, 3, 3F, 4, 4BC, 4RB, 5, 5H, 5SB, 5R and 5WV	**Exposure 1** Average ≥ 5.7 (25)
					4B and 4H	**Exposure 1** Average ≥ 36 (160)
					4B and 4H	**Exposure 2a** Average ≥ 22 (96) or **Exposure 2b** Average ≥ 14 (64)
					1, 1F, 2, 2F, 3, 3F, 4, 4BC, 4RB, 5, 5H, 5SB, 5R and 5WV	**Exposure 2a or 2b** Average ≥ 5.1 (23)

[a] See Table 2.2 for conditioning details.

[b] Colors - lightest and darkest.

[c] *Deleted*

[d] See Table 2.1 for an explanation of Use Code designations.

5.2 For the loop breaking strength test, the test machine described in the Standard Test Methods for Sewing Threads, ASTM D204 is to be used. Both ends of one piece are to be secured in one clamp of the testing machine so that the length of the loop equals one-half the total length between the jaws. One end of the second piece is to be passed through the loop formed by the first, and both ends of the second piece are to be secured in the other clamp of the machine. The clamps are to be separated at a rate of 12 ±0.5 inches per min (305 ±12.7 mm per min).

6 Marking

6.1 Each spool of thread and each shipping label shall be permanently and clearly marked with the following information in a color which contrasts with the color of the surface on which the marking is to be applied:

a) The manufacturer's name, tradename, or symbol;

b) The style (model) number of the thread;

c) The size of the thread, unless a unique style (model) number is provided for each size;

d) The lot number of the thread; and

e) Use Code(s).

FABRIC

7 Construction

7.1 Fabric used as drainage material in a structural application (for example, when removed, the device does not function as intended) shall comply with all of the applicable fabric requirements for the specific PFD for which it is intended.

8 Performance

8.1 General

8.1.1 Fabric shall comply with the acceptance criteria specified in Table 8.1 when subjected to the tests in this Section.

8.1.2 Separate samples are to be used for each different conditioning exposure.

8.2 Yarn slippage – woven fabric only

8.2.1 The warp samples specified in Table 8.1 are to be cut with the long dimension parallel to the warp yarns and filling samples are to be cut with the long dimension parallel to the filling yarns. No two warp samples are to contain the same warp yarns and no two filling samples are to contain the same filling yarns. No sample is to include selvage.

8.2.2 The narrow end of the sample is to be inserted approximately 1/4 inch (6.35 mm) into the nine-hole chuck illustrated in Figure 8.1 and centered. A nine-needle bit is to be aligned with the holes in the chuck so that the smooth side of the needles faces the 1/4 inch (6.35 mm) edge of the sample. The needles are to be forced through the fabric past the scarf joint so that the fabric lays against the blade of the needles.

8.2.3 The tensile machine is to be a Constant-Rate-of-Traverse (CRT) or Constant-Rate-of-Extension (CRE). The tensile machine is to be equipped with clamps having front jaws 1 x 1 inches (25.4 mm x 25.4 mm) and back jaws 1 x 1.5 inches (25.4 mm x 38.1 mm) or wider. The nine-hole chuck is to be centered and clamped in the upper jaws of the machine so the sample hangs lengthwise. The holes in the chuck are be perpendicular to the direction of pull. The fabric is to be clamped to the lower jaws of the machine. Separation between the holes in the chuck and the top of the jaws is to be 2.5 inches (63.5 mm). The yarns are to be parallel to the direction of pull. The jaws are then to be separated at a rate of 12 ±0.5 inches (305 ±12.7 mm) per min. The maximum force required to cause rupture is to be recorded.

8.3 Openness of weave

8.3.1 The openness of weave, see Table 8.1, is to be determined using a full width sample at least 1 yard (0.9 m) long. Five separate measurements are to be taken across the width of the roll. For each measurement a 1 inch square (645 mm^2) is to be marked on the fabric. No measurement is to be within 1 inch (25.4 mm) of the selvage edge.

8.3.2 In the area of the marked fabric material, the size of each opening is to be measured using an optical comparator with a magnification sufficient to determine the size of each opening (i.e. 5X). Openings on the edge of a 1 inch square are to be counted as one whole opening only when more than 1/2 of the opening is inside the marked square. The openness of the weave is to be calculated as follows:

$$O_W = 100 \sum_{i=1}^{N} \frac{T_A}{N \times 1\ inch^2}$$

In which:

O_W = *Openness of Weave*

N = Number of 1 inch squares

T_A = *Total Area of all opening (inch^2)*

Table 8.1
Fabric

Tests	Exposure[a]	Number of samples[b]	Sample size[c] inch (mm)	Use Codes[d]	Compliance criteria pounds-force N)
Breaking Load (Woven fabrics only) per ASTM D5034-90 (G-E or G-T)	**1.** SC **2a.** Xe_{500} **2b.** Xe_{750} or Nt_{75} **3.** 70 h immersion in ASTM Ref. Fuel B. **4.** 70 h immersion in IRM 902 (Calumet Oil No. 2). **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water.	5 warp and 5 fill for each separate exposure[e]	4 x 6 (102 x 152)[e]	2, 3, 4BC and 5R 1, 1F, 2F, 3F, 4, 4B, 4H, 4RB, 5, 5H, and 5WV 2, 3, 4BC and 5R 1, 1F, 2F, 3F, 4, 4B, 4H, 4RB, 5, 5H and 5WV 3, 4, 4BC, and 5R 1, 1F, 2F, 3F, 4, 4B, 4H, 4RB, 5, 5H and 5WV	**Exposure 1** Average ≥ 70 (311) in each direction **Exposure 1** Average ≥ 90 (400) in each direction **Exposure 2a** Average ≥ 40 (178) in each direction, or **Exposure 2b** Average ≥ 25 (111) in each direction **Exposure 2a** Average ≥ 60 (267) in each direction, or **Exposure 2b** Average ≥ 40 (178) in each direction **Exposure 3 through 5** Average ≥ 70 (311) **Exposure 3 through 5** Average ≥ 90 (400)
Ball Burst (knitted fabrics only) per ASTM D3787	Same as Breaking Load (Woven fabrics)	10 for each separate exposure	5 x 5 (127 x 127)	All 2, 3, 4BC, and 5R 1, 1F, 2F, 3F, 4, 4B, 4H, 4RB, 5, 5H, and 5WV	**Exposure 1, and 3 – 5** Average ≥ 130 (578) **Exposure 2a** Average ≥ 130 (578), or **Exposure 2b** Average ≥ 46 (205) **Exposure 2a** Average ≥ 130 (578), or **Exposure 2b** Average ≥ 74 (329)
Tearing Strength (woven fabrics only) per ASTM D2261	SC	5 warp and 5 fill`	3 x 8 (76 x 203)	2, 3, 4BC, and 5R 1, 1F, 2F, 3F, 4, 4B, 4H, 4RB, 5, 5H, and 5WV	Average ≥ 6.0 (26.7) in each direction Average ≥ 8.5 (37.8) in each direction
Yarn Slippage (Woven Fabric	SC	5 warp and 5 fill	4 x 6 (102 x 152)	All	Average ≥ 50 (220) in each direction

Table 8.1 Continued on Next Page

Table 8.1 Continued

Tests	Exposure[a]	Number of samples[b]	Sample size[c] inch (mm)	Use Codes[d]	Compliance criteria pounds-force N)
only) per nine needle apparatus test (See 8.2)					
Openness of Weave[g] (See 8.3)	SC	5	1 linear yard Full width	All	Shall not exceed 20 percent.
Adhesion Strength[f] per ASTM D751	SC	2 warp and 2 fill	2 x 8 (51 x 203) or 3 x 8 (76 x 203)	All	Shall be at least 4 pounds per inch (18).

[a] See Table 2.2 for conditioning details.

[b] Color dependent. See 2.4.

[c] *Deleted*

[d] See Table 2.1 for an explanation of Use Code designations.

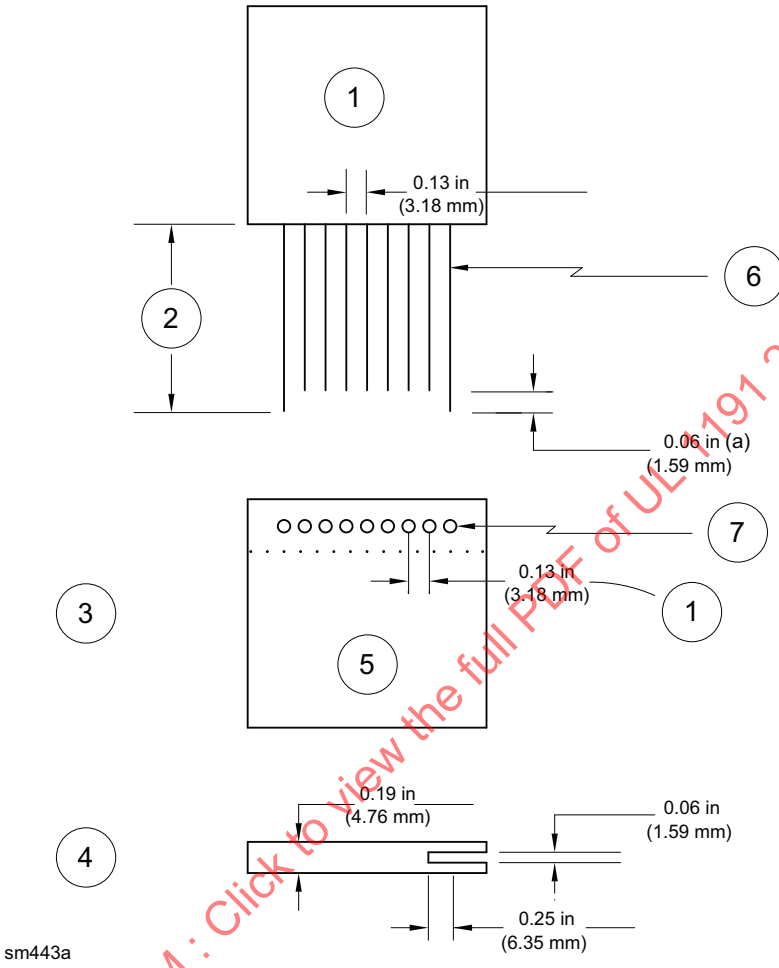
[e] Sample requirements determined based on exposure facilities, number of fabric colors needing to be evaluated, and sample requirements for accelerated weathering correlation of natural weathering results.

[f] Applies only to coated fabric with a coating of 5.5 oz/yd^2 or more and where the base fabric or scrim does not comply with the applicable strength requirements when fabric is uncoated.

[g] May not apply to gusset, lining, or drainage fabric.

Figure 8.1

Nine needle apparatus



Key

1 – Spacing

2 – Minimum 3/8"

3 – Nine hole spacer – Top View

4 – Side View (Rotated 90°)

5 – Grip area for 1" by 1" jaws

6 – Nine – size 18 singer thin ball point needles (b)

7 – Nine 1/16" thru-holes

Notes:

(a) This spacing is optional. All needles are able to extend the same distance.

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

9 Marking

9.1 Each shipping label shall be clearly and permanently marked in a color which contrasts with a color of the surface on which the marking is applied, with the following:

a) Recognized company name, or tradename, or symbol;

b) Style designation;

c) Lot number; and

d) One or more of the Use Code(s) specified for the product.

WEBBING AND TIE TAPE

10 Construction

10.1 Webbing shall be nominally 3/4 inch (19 mm) wide or wider for Use Codes 2C and 3C, nominally 2 inches (50.8 mm) wide or wider for Use Codes 4RB and 4B, and nominally 1 inch (25.44 mm) wide or wider for all other Use Codes.

10.2 Tie tape shall be nominally 1 inch (25.4 mm) wide or wider for Use Codes 1 and 1F and nominally 3/4 inch (19 mm) wide or wider for all other Use Codes.

11 Performance

11.1 General

11.1.1 Webbing and tie tape shall comply with the acceptance criteria specified in Table 11.1 and Table 11.2, respectively, when subjected to the tests therein.

11.2 Friction

11.2.1 Three samples each consisting of one 10 inch (254 mm) long piece and two 5 inch (127 mm) long pieces as specified in Table 11.2, are to be used. Each 10 inch sample is to be centered between the two 5 inch samples to form a 90 degree cross. A 35 pound (16 kg) dead weight is to be placed on the intersection of the three pieces. A metal guide is then to be placed on top of this assembly. At the point of contact, the cross sectional area of the weight is to be approximately 1 square inch (645.2 mm^2). The guide is constructed to:

a) Hold the 5 inch (127 mm) pieces rigidly in place 2 inches (51 mm) on each side of the intersection; and

b) Maintain the dead load weight directly over the intersection during the test. A force gauge is to be clamped to an end of the 10 inch (254 mm) piece.

The force required to initiate slippage of the 10 inch (254 mm) piece between the two 5 inch (127 mm) pieces under the 35 pound (16 kg) load is to be recorded.

11.3 Flexibility

11.3.1 Each sample specified in Table 11.2, as applicable, is to be secured between two, 1/2 inch (12.7 mm) wide metal bars so that the cut edges of the sample are flush with the bottom edge of the bars to form a loop around the bars at a 90 degree angle to the bars. During this set-up, the sample is not to be creased. The sample is to be positioned vertically and left to hang for 1 min. The distance from the bottom

of the bars to the interior of the bottom of the loop (i.e., the loop length) is to be measured and recorded. The procedure is then to be repeated by taking the webbing out and turning it over. The values, both before and after being turned over are to be used in calculating the average.

11.4 Strength/slippage

11.4.1 *Deleted*

11.4.2 *Deleted*

Figure 11.1

Fixed straight-length method

Figure deleted

11.5 Torsional stiffness

11.5.1 Three samples are to be used.

11.5.2 The samples specified in Table 11.2 are to be laid flat on a hard surface, straight, and not under tension. One end of the sample is to be marked as the reference end. Marks are to be placed on the sample 1-1/4 inches (32 mm) and 36 inches (0.9 m) from the reference end.

11.5.3 The reference end of the sample is to be held in a clamping surface by taking the end of the strip at the reference end and folding it over until the end is even with the mark drawn 1-1/4 inches (32 mm) from the reference end. The reference end is then to be placed in a fabric clamp in accordance with the Test Methods for Breaking Load and Elongation of Textile Fabrics, ASTM D5034-90, centered and perpendicular to the clamp bars.

11.5.4 The end opposite the reference end is to be placed in a clamp. The clamping surface area is 1/2 x 4-1/2 inches (12.7 x 114.3 mm) and the jaws are not padded. The end of the strip is to be placed in the jaws of the clamp so that the 36 inch (0.9 m) mark is even with the outside bottom edge of the larger jaw of the clamp. The distance between the fabric clamp and the upper jaw is to be 34-3/4 inches (882 mm).

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

11.5.6 The fabric clamp is then to be rotated five complete turns in the clockwise direction and released. The sample is allowed to unwind (counterclockwise), allowed to pass the point of zero twists, and allowed to continue in the counterclockwise direction until it stops winding in the direction momentarily. The time from which the sample was released until the counterclockwise twisting motion first pauses is to be recorded. The clamp is to be returned to its initial position. For tie-tape material that has a unsymmetrical weave, the procedure is then to be repeated with the sample rotated counterclockwise.

Table 11.1
Webbing

Tests	Exposure[a]	Number of samples[b]	Sample size inch (mm)	Use codes[c]	Compliance criteria pounds-force (N)
Breaking Strength per ASTM D5035 Method 4108	**1.** SC **2a.** Xe_{500} **2b.** Xe_{750} or Nt_{75} **2c.** Xe_{1380} or Nt_{138}	5 for each separate exposure	48 (1.2 m)	1, 1F, 2F, 3F, 5, 5WV and 5H	**Exposures 1** Average ≥ 400 (1776)
				2, 3 4BC, and 5R	**Exposures 1** Average ≥ 200 (888)
				2C and 3C	**Exposures 1** Average ≥ 115 (511)
				4, 4B, 4H, and 4RB	**Exposures 1** Average ≥ 750 lbs (3330 N) per inch of width
				1, 1F, 2F, 3F, 5, 5WV and 5H	**Exposure 2a** Average ≥ 400 (1776) or **Exposure 2b** Average ≥ 160 (711) 1, 1F, 2F, 3F, 5, 5WV and 5H
				All except 1F, 2F, 3F, 5, 5WV, and 5H	**Exposure 2a** Average ≥ 240 (1067) or **Exposure 2b** Average ≥ 160 (711)
				2, 3 4BC, and 5R	**Exposure 2a** Average ≥ 120 (533) or **Exposure 2b** Average ≥ 80 (355)
				2C and 3C	**Exposure 2a** Average ≥ 69 (306) or **Exposure 2b** Average ≥ 46 (204)
				4, 4B, 4H, and 4RB	**Exposures 2a** Average ≥ 450 lbs (270 N) per inch of width or **Exposure 2b** Average ≥ 300 (1334) per in of width **Exposure 2c** Average ≥ 600 (1335) for all widths less than 2 inches for all colors except black

[a] See Table 2.2 for conditioning details.

[b] Colors – lightest and darkest.

[c] See Table 2.1 for an explanation of Use Code designations.

[d] *Deleted*

Table 11.2
Tie tape

Tests	Exposure[a]	Test method	Number of samples	Sample size[b] inch (mm)	Use codes[c]	Compliance criteria pounds-force (N)
Breaking Load	**1.** SC **2a.** Xe_{500} **2b.** Xe_{750} or Nt_{75}	ASTM D5035	10[b,c]	54 (1.3 m)	2, 3, and 5R 1, 1F, 2F, 3F, 5 and 5H All except 1F, 2F, 3F and 5H 1F, 2F, 3F and 5H	**Exposure 1** Average ≥ 120 (533) **Exposure 1** Average ≥ 200 (888) **Exposure 2a** Average ≥ 72 (320) or **Exposure 2b** Average ≥ 48 (214) **Exposure 2b** Average ≥ 80 (356)
Flexibility	SC	See 11.3.1	3 for each separate test	10 (254)	All	Average ≥ 1.5 inches (38 mm)
Friction	SC	See 11.2.1		3 pieces 10 (254) or 6 pieces 5 (127)	All	Average ≥ 18 (80)
Torsional Stiffness	SC	See 11.5.1 – 11.5.6		40 (1.0 m)	All	Average ≥ 5 s

[a] See Table 2.2 for conditioning details.

[b] Colors – lightest and darkest.

[c] See Table 2.1 for an explanation of Use Code designations.

12 Marking

12.1 Each shipping label shall be permanently and clearly marked in a color which contrasts with the color of the surface on which the marking is applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) The product's style designation;

c) The width of the product in inches;

d) Lot number; and

e) Use Code(s).

LACING

13 Construction

13.1 Lacing shall be nominally 1/8 inch (3.2 mm) in diameter or nominally 1/4 inch (6.35 mm) wide.

14 Performance

14.1 General

14.1.1 Lacing shall comply with the acceptance criteria specified in Table 14.1 when subjected to the tests therein.

14.2 Untieability

14.2.1 The samples specified in Table 14.1 are to be given to test subjects who are to be instructed to "tie the lacing into a square knot and pull the knot snug." The subjects are then to be instructed to "untie the square knot as quickly as possible." The time to untie the square knot is to be recorded.

Table 14.1
Lacing

Tests	Exposure[a]	Test method	Number of samples[b]	Sample size[c] inch (mm)	Use codes[d]	Compliance criteria pounds-force (N)
Ultimate Breaking Strength	**1.** SC **2a.** Xe_{500} **2b.** Xe_{750} or Nt_{75}	ASTM D5035; except separation 12 ±0.5 inch per min	5 for each separate conditioning	54 (1.4 m)	2, 2F, 3, 3F, 5, 5H and 5R 2, 3, and 5R 2F, 3F, 5, and 5H	**Exposure 1 and 2a or 2b** Average ≥ 120 (533) **Exposure 2a** Average ≥ 72 (320) or **Exposure 2b** Average ≥ 48 (214) **Exposure 2b** Average ≥ 48 (214)
Untieability	**1.** Tied and Untied at Standard Conditioning **2.** Tied and Untied after 1 min Water Soak **3.** Tied after Standard Conditioning and Untied after 1 min Water Soak	See 14.2.1	2	36 (914)	All	Each of the five test subjects shall be able to untie the square knot within 1 min following exposures 1 – 3

[a] See Table 2.2 for conditioning details.

[b] Color – lightest and darkest.

[c] *Deleted*

[d] See Table 2.1 for an explanation of Use Code designations.

15 Marking

15.1 Each shipping label used for the smallest carton shipped shall be clearly and permanently marked in a contrasting color with the following:

a) Manufacturer's name, tradename, or symbol;

b) The product's style designation;

c) The width or diameter of the product in inches;

d) Lot number; and

e) Use Code(s).

ZIPPERS

16 Construction

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

16.2 For the purpose of these requirements the Definitions of Terms Relating to Zippers, ASTM D2050 apply.

17 Performance

17.1 General

17.1.1 Zippers shall comply with the acceptance criteria specified in Table 17.1 for PFDs and Table 17.2 for immersion suits when subjected to the tests therein.

Table 17.1
Zippers for PFDs

Tests	Exposure[a]	Test method	Number of samples[b,c]	Sample size inch (mm)	Use codes[d]	Compliance criteria pounds-force (N)
Operability Force	**1.** SC **2a.** Xe_{500} [f] **2b.** Xe_{750} [f] or Nt_{75} **3.** 70 h immersion in ASTM Ref. Fuel B[g] **4.** 70 h immersion in IRM 902 (Calumet Oil No.2)[g] **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water[g] **6.** 720 h of salt spray as specified in ASTM B117-94[e]	ASTM D2062-93 See 17.2.1.	Six for each separate exposure	6 (152)	2, 3, and 5 2F, 3F and 5H	**Exposures 1, 3 – 6, and 2a or 2b** Open and Close Force ≤ 15 (67) **Exposures 1 – 6, except 2a** Open and Close Force ≤ 15 (67)
Crosswise Strength	Same samples as Operability Force	ASTM D2061-93 except for top of zipper (including slider) and bottom of zipper (for moveable retainer) See 17.3.2	The samples used in the Operability Force Tests.	6 (152)	2, 2F, 3, 3F, 5 and 5H 2, 2F, 3, 3F, 5 and 5H 2F, 3F, and 5H	**Exposures 1 – 6, except 2b** Average ≥ 50 (222) for the top (including slider) and the chain (crosswise). Average ≥ 30 (133) for the separating unit (crosswise). **Exposures 2a – 6, except 2b** Average ≥ 30 (133) **Exposure 2b** Average ≥ 20 (89)

Table 17.1 Continued on Next Page

Table 17.1 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Sample size inch (mm)	Use codes[d]	Compliance criteria pounds-force (N)
Resistance to Pull-Off of Slider Pull	SC	ASTM D2061-93	3	6 (152)	2, 2F, 3, 3F, 5, and 5H.	The pull-and-slider zipper assembly shall not dislodge when subjected to a force of 40 (177).
Resistance to Twist of Pull and Slider	SC	ASTM D2061-93	4 (2 for each direction)	6 (152)	2, 2F, 3, 3F, 5, and 5H.	The pull and slider shall resist a force of 7 lbf·in (0.79 N·m) torsional stress without significant deformation or rupture.
Holding Strength of Slider Lock	SC	ASTM D2061-93	3	6 (152)	2, 2F, 3, 3F, 5, and 5H.	The locking mechanism shall remain locked when subjected to a force of 5 (22) and the slider shall be operable following the test .

[a] See Table 2.2 and 17.2.1 for conditioning details.

[b] Colors – lightest and darkest.

[c] *Deleted*

[d] See Table 2.1 for an explanation of the Use Code designations

[e] Applies to zippers employing metallic parts; except certified AISI 300 or 400 series stainless steel or equivalent corrosion resistant metals.

[f] Mount each of 3 samples vertically so the top of sample 1, the center of chain of sample 2, and the bottom of sample 3 are in the same plane as the horizontal centerline of the source of radiation. The outer side of the samples is to face the light source. See 17.2.1.

[g] Samples are to be blotted dry to remove surface moisture and are to rest for no less than 30 min at ambient room temperature prior to the operability force and strength tests.

Table 17.2
Zippers for Immersion Suits

Tests	Exposure[a]	Test method	Number of samples	Sample size inch (mm)	Use codes[b]	Compliance criteria pounds-force (N)
Opening and Close Force	**1.** SC **2.** 720 h of salt spray as specified in ASTM B117[c,f] **3.** 24 h under a 100 mm head of No. 2 marine diesel oil at 18 – 20°C.[d,f] **4.** Temperature Cycling (repeat 5 times)[e] a. 8 h at 65°C b. 8 h at 20°C c. 8 h at -30°C d. 8 h at 20°C	ASTM D2062	Five for each separate exposure	750	6I	**Exposure 1** Open and Close Force ≤ 40 N **Exposures 2 and 3** Open and Close Force ≤ 175 N **Exposure 4** Open and Close Force ≤ 60 N
Crosswise Strength	Same samples as Opening and	ASTM D2061 except for top of zipper (including	Same samples as Opening and	Same samples as Opening	6I	**Exposures 1 – 4** Average ≥ 440 N for top, bottom end and center

Table 17.2 Continued on Next Page

Table 17.2 Continued

Tests	Exposure[a]	Test method	Number of samples	Sample size inch (mm)	Use codes[b]	Compliance criteria pounds-force (N)
	Close Force Test	slider) and bottom of zipper (for moveable retainer) See 17.3.2	Close Force Test	and Close Force Test		
Leak Resistance	CGSB 65.16. Sec. 6.3.6.4.	CGSB 65.16. Sec. 6.3.6.4.	2	356	6I	CGSB 65.16. Sec. 6.3.6.4.

[a] See Table 2.2 and 17.2.1 for conditioning details.

[b] See Table 2.1 for an explanation of the Use Code designations.

[c] Applies to zippers employing metallic parts.

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

[e] Testing shall occur after the sequence has occurred 5 times.

[f] Zippers shall be conditioned with the slide at midpoint on the chain.

17.2 Operability force test

17.2.1 For each set of six samples (see Table 17.1), three are to be used to determine the force required to open the zipper, and three are to be used to determine the force required to close the zipper. Samples for opening force are to be closed for conditioning. Samples for closing force are to be open (separated) for conditioning. Tests are to be conducted on the slider and on the moveable retainer, when provided.

17.3 Crosswise strength test

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

17.3.2 The following tests are to be conducted in accordance with the Methods for Strength Tests for Zippers, ASTM D2061-93:

a) For the chain (crosswise); and

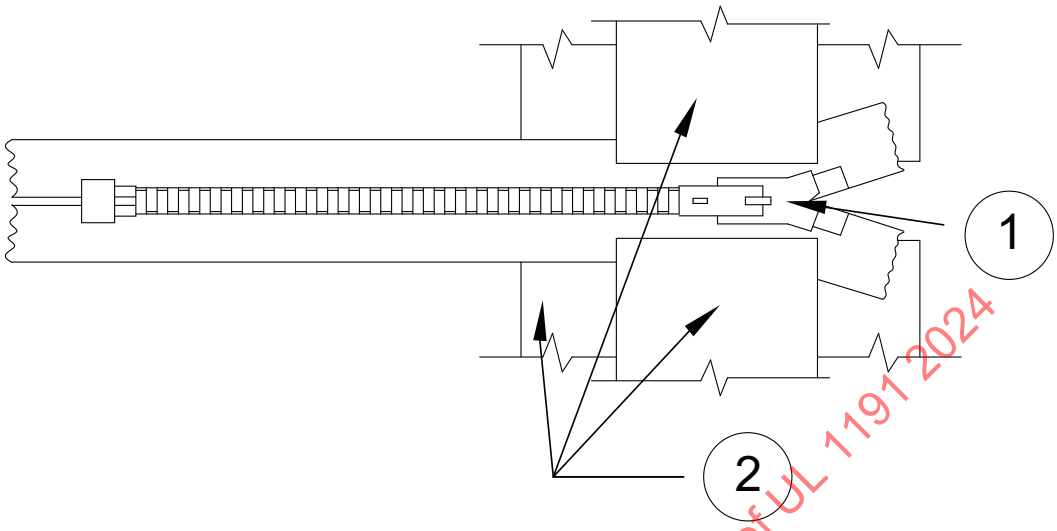
b) For a separating unit (crosswise), or for a bottom stop holding (crosswise).

17.3.3 The test described in 17.3.4 is to be conducted for the test at the top of the zipper including slider, and for the test at the bottom of the zipper when a moveable retainer (second slider) is used.

17.3.4 The apparatus used for the strength test at the top of the zipper including the slider, and for the test at the bottom of the zipper when a moveable retainer (second slider) is used, is to be as described in the Test Methods for Strength Tests for Zippers, ASTM D2061-93. The tapes of each zipper are to be mounted in the clamps of the tension machine as illustrated in Figure 17.1 with the edges of the jaws parallel to, and approximately 1/8 inch (3 mm) from the sides of the slider. The slides are to be positioned so that the exposed end of the slider is aligned with the sides of the front jaws as illustrated in Figure 17.1. The load is to be applied until the slider comes apart, until the tape breaks or until some other kind of malfunction occurs. The maximum load to obtain rupture is to be recorded.

Figure 17.1

Crosswise strength test top (including slider)



s2686b

1 – Slider

2 – Testing machine clamps, 1 inch (25.4 mm) wide front and 2 inch (50.8 mm) wide back

18 Marking

18.1 Each shipping label shall be permanently and clearly marked with the following in a color that contrasts with the color of the surface on which the marking is applied:

a) Manufacturer's name, tradename, or symbol;

b) Model number;

c) Lot number; and

d) Use Code(s).

18.2 Each zipper slider or pull shall be marked with the manufacturer's name, tradename, or symbol.

HARDWARE

19 Webbing Closures and Adjusters

19.1 General

19.1.1 Closures and adjusters, such as buckles, slide adjusters, snaphooks, Dee rings, and hook and eye clasps shall comply with the compliance criteria specified in Table 19.2 when subjected to the tests therein.

19.2 Construction

19.2.1 A closure or adjuster shall be constructed to accommodate webbing in one of the following nominal widths: 3/4, 1, 1-1/4, 1-1/2, or 2 inches (19, 25, 32, 38, or 51 mm).

19.2.2 For Use Codes, 1, 2, 3, 1F, 2F, 3F, 2C, and 3C, the primary webbing closure hardware shall have a quick and positive lock mechanism.

19.3 Performance

19.3.1 Ultimate breaking strength

19.3.1.1 Each assembly is to consist of the conditioned sample with two lengths of 6 inches (152.4 mm) of unconditioned webbing of the appropriate size and tested in accordance with Table 11.1 attached as they are for use.

19.3.1.2 The tester used is to be a constant-rate-of-extension Tensile Test machine as described in the Specification for Tensile Testing Machines for Textiles, ASTM D76-93 with a rate-of-extension of 12 ±0.5 inch (305 ±12.7 mm) per min. The front and back jaws of the clamps are to be at least as wide as the webbing being used on the samples. The gage length shall be 2 +1/4, -0 inches (51 +6.3, -0 mm) longer than the length of the sample being tested.

19.3.1.3 The sample is to be mounted in the tensile machine by securing each length of webbing in opposite clamps so that the sample is centered between the clamps both vertically and horizontally. For the end of the sample in which friction adjustment of the webbing is possible, only the end of that piece of webbing which results in the binding of the webbing to the hardware when under load is to be secured to the clamps. The clamps are to be separated until breakage, disengagement, webbing slippage in excess of 3 inches (76.2 mm) or similar condition occurs. The maximum value (breaking load) to result in failure is to be recorded.

Table 19.1
Webbing specifications for breaking strength test
Table deleted

19.3.2 Strength/slippage

19.3.2.1 *Deleted*

19.3.2.2 *Deleted*

Table 19.2
Webbing Closures and Adjusters

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use code[d]	Compliance criteria pounds-force (N)
Ultimate Breaking Strength [l]	**1.** SC **2a.** Xe_{500}[g] **2b.** Xe_{750} or Nt_{75}[g] **3.** 70 h immersion in ASTM Ref. Fuel B[e] **4.** 70 h immersion in IRM 902 (Calumet Oil No. 2)[e] **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water[e] **6.** 70 ±2°C (158 ±40F) for 7 days[e]. **7.** -30 ±2°C (-22 ±40F) for 24 h.[i] **8.** 720 h of Salt Spray as specified in ASTM B117-94.[f] **9.** Fatigue[j]	19.3.1.1 – 19.3.1.3	5 for each separate conditioning	1, 1F, and 5 2F, 3F, 5WV, and 5H 2, 3, 4H, and 5R 2C and 3C 2, 3, 4H, and 5R 1, 1F, and 5 2F, 3F, 5WV, and 5H 2, 3, 4H, and 5R 2C and 3C 1, 1F, and 5 2F, 3F, 5WV, and 5H 2, 3, 4H, and 5R 2C and 3C 1, 1F, and 5 2F, 3F, 5WV, and 5H 2, 3, 4H, and 5R 2C and 3C 1F, 2F, 3F, and 5H	**Exposures 1 – 9, except 2b** Minimum ≥ 360 (1600) **Exposures 1 – 9, except 2b** Minimum ≥ 225 (1000) **Exposure 1** Minimum ≥ 200 (888) **Exposures 1 – 9, except 2b** Minimum ≥ 115 (512) **Exposures 2a – 9, except 2b** Minimum ≥ 150 (666) **Exposure 2a** Average ≥ 216 (961) Average ≥ 135 (601) Average ≥ 120 (534) Average ≥ 115 (512) or **Exposure 2b** Average ≥ 144 (641) Average ≥ 90 (401) Average ≥ 80 (356) Average ≥ 46 (205) **Exposures 3 – 7 and 9** Average ≥ 216 (961) Average ≥ 135 (601) Average ≥ 120 (534) Average ≥ 69 (306) **Exposure 2b** Average ≥ 144 (641)
Inadvertent Release Test (Dual-tab closures only)	SC	19.3.3.1 and 19.3.3.2	5	1, 1F, 2, 2F, 2C, 3, 3F, 3C, 4H, 5, 5WV, 5H, and 5R	Each sample shall support for 5 min without breaking, disengagement, or similar condition, a load of at least 1/2 the minimum breaking strength specified for exposure 1 in the Ultimate Breaking Strength Test using webbing Type II.

[a] See Table 2.2 for conditioning details.

[b] Color – lightest and darkest for polymeric hardware only.

[c] For polymeric hardware, a minimum of 75 hardware/webbing. For metal hardware, 30 hardware/webbing Type II assemblies.

[d] See Table 2.1 for an explanation of Use Code designations

Table 19.2 Continued on Next Page

Table 19.2 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use code[d]	Compliance criteria pounds-force (N)
[e] Samples are to be blotted dry to remove surface moisture and are to rest for no less than 30 min at ambient room temperature prior to the strength test.					
[f] Metallic hardware only. Not applicable to certified AISI 300 or 400 series stainless steel or equivalent corrosion resistant materials.					
[g] Each sample is to be routed with webbing. Mount each sample vertically, unbuckled, so the center of the sample is in the same plane as the horizontal centerline of the source of normal radiation. The outside face of the samples is to face the arcs. Replace webbing before testing.					
[h] *Deleted*					
[i] Within 30 s following removal from the cold chamber, the samples are to be dropped using different orientations onto a concrete floor five times from a height of 6 feet (1.8 m). Each sample is then to be manually operated five times and then examined for signs of cracking. The samples are then to be returned to the cold chamber for 15 min. The samples are then to be individually removed and subjected to the Ultimate Breaking Strength Test.					
[j] Each flexible or moveable tab of polymeric part is to be mechanically operated 5000 cycles at a rate of 40 to 60 cycles per min. The tab is to be completely engaged/disengaged. Also, for hardware which is designed to separate into two parts (i.e., buckles), the parts are to be completely engaged/disengaged. In addition, the samples are to be manually operated 5 times prior to the Ultimate Breaking Strength Test.					
[k] *Deleted*					
[l] For metallic hardware, only exposures 1 and 8 are applicable.					

19.3.3 Inadvertent release test – dual-tab closures

19.3.3.1 With one tab depressed, the samples shall comply with the compliance criteria specified in Table 19.2.

19.3.3.2 The webbing assembly and test method are to be as described for the Fixed Length Body Strap test method specified in 19.3.2.1 (see Figure 19.1); except one tab is to be depressed. A 5 ±1 pound pre-load is to be applied to each closure so that when the release tab is depressed it does not slip back into the locked position. The remaining load is then to be applied.

19.4 Marking

19.4.1 Each shipping carton label for all devices shall be permanently and clearly marked in a color which contrasts with the color of the surface on which the markings are applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) Model number;

c) Lot Number; and

d) Use Code(s).

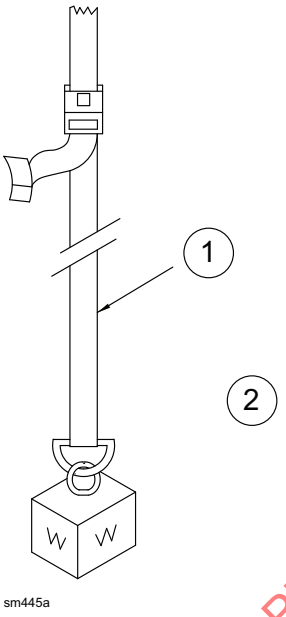
19.4.2 Each singular polymeric hardware device (i.e., one physical piece such as a slide) shall be permanently marked with the following:

a) Manufacturer's name, tradename, or symbol; and

b) Model number.

Figure 19.1

Fixed straight-length method



1 – Fixed length body strap (no loop)

2 – Approximate length of webbing = 24 inches

19.4.3 Each part of a multi-part polymeric hardware device (i.e., at least two physical mating pieces such as a buckle) shall be packaged together and marked with the information specified in 19.4.2 (a) and (b).

Exception: Parts of a multi-part polymeric hardware device which have less than 0.25 square inches (161.3 mm^2) of surface area on each face, are not required to comply when at least one part is marked.

20 Lacing Closures and Adjusters

20.1 General

20.1.1 Closures and adjusters for lacing used in a primary or secondary closure or adjustment systems, shall comply with the compliance criteria specified in Table 20.1 when subjected to the tests therein.

20.2 Construction

20.2.1 A lacing closure or adjuster is capable of being constructed to accommodate lacing in any appropriate nominal diameter.

20.3 Performance

20.3.1 Ultimate breaking strength

20.3.1.1 Each assembly is to consist of the sample with two lengths of 6 inches (152.4 mm) of lacing attached as they are for use. For hardware that depends on friction for adjustment of the lacing, any adjustment tab is to be depressed with a force of 1 pound (.45 kg) to secure the lacing prior to testing.

20.3.1.2 The tester is to be a constant-rate-of-extension Tensile Test machine as described in the Specification for Tensile Testing Machines for Textiles, ASTM D76-93 with a rate-of-extension of 12 ±0.5 inch (305 ±12.7 mm) per min. The front and back jaws of the clamps are to be at least as wide as the lacing being used on the samples. The gage length shall be 2 +1/4, -0 inches (51 +6.3, -0 mm) longer than the width of the sample being tested.

20.3.1.3 The sample is to be mounted in the tensile machine by securing each length of lacing in opposite clamps so that the lacing grip area of the sample is centered between the clamps both vertically and horizontally. Only the ends of the lacing which results in the binding of the lacing to the hardware when under load is to be secured to the clamps. The clamps are to be separated until breakage, disengagement, lacing slippage in excess of 3 inches (76.2 mm) or similar condition occurs. The maximum value (breaking load) to cause failure to be recorded.

20.3.2 Strength/slippage

20.3.2.1 *Deleted*

20.3.2.2 *Deleted*

20.3.2.3 *Deleted*

20.3.3 Tab disengagement test

20.3.3.1 Each assembly is to consist of the sample with two lengths of 24 inches (0.6 m) of lacing attached as they are for use. For hardware that depends on friction for adjustment of the lacing, any adjustment tab is to be depressed with a force of 1 pound (.45 kg) to secure the lacing prior to testing.

20.3.3.2 One of the lacing ends that results in the binding of the lacing to the hardware is to be secured in a rigid fixture. The other lacing end that result in the binding of the lacing to the hardware is to be attached to a 5 pound (2.27 kg) deadweight. The deadweight is to be suspended from the lacing and then raised 12 inches (304.8 mm) from the suspended position. The deadweight is then to be released so a shock load is applied to the sample..

Table 20.1
Lacing closures and adjusters

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use codes[d]	Compliance criteria pounds-force (N)
Ultimate Breaking Strength[l]	**1.** SC **2a.** Xe_{500} [g] **2b.** Xe_{750} or Nt_{75} [g] **3.** 70 h immersion in ASTM Ref. Fuel B[e] **4.** 70 h immersion in IRM 902 (Calumet Oil No. 2)[e] **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water[e] **6.** 70 ±2°C (158 ±4°F) for 7 days[e] **7.** -30 ±2°C (-22 ±4°F)[i] **8.** 720 h of Salt Spray as specified in ASTM B117-94[f] **9.** Fatigue[i]	20.3.1.1 – 20.3.1.3	5 for each separate conditioning	2, 3, and 5R (Primary adjustment used in multi-routed side lacing.)	**Exposure 1, 2a, and 3 – 9.** Minimum ≥ 150 (666) divided by the minimum number of lacing passes
				2F, 3F, 5 and 5H (Primary adjustment used in multi-routed side lacing).	**Exposure 1, 2a, and 3 – 9.** Minimum ≥ 225 (1008) divided by the minimum number of lacing passes.
				2, 2F, 3, 3F, 5, and 5H (Secondary closure or adjustment use in encircling drawstrings)	**Exposure 1, 2a, and 3 – 9.** Minimum ≥ 70 (311)
				2, 3, and 5R	**Exposure 3 – 9.** Average ≥ 90 (399)
				2F, 3F, 5 and 5H	Average ≥ 135 (604)
				2, 3, 5R	**Exposure 2a** Average ≥ 90 (399) or **Exposure 2b** Average ≥ 60 (266)
				2F, 3F, 5, and 5H	**Exposure 2b** Average ≥ 90 (403)
Tab Disengagement Test	SC	20.3.3.1 and 20.3.3.2	5	2F, 3F, 5 and 5H	A moveable tab shall remain engaged and operable when subjected to a shock load of 5 foot-pounds.

[a] See Table 2.2 for conditioning details.

[b] Color – lightest and darkest for polymeric hardware only.

[c] For polymeric hardware, a minimum of 80 samples. For metal hardware, 35 hardware samples.

[d] See Table 2.1 for an explanation of Use Code designations.

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

[f] Metallic hardware only. Not applicable to certified AISI 300 or 400 series stainless steel or equivalent corrosion resistant materials.

[g] Each sample is to be routed with lacing. Mount each sample vertically so the center of the sample is in the same plane as the horizontal centerline of the source of normal radiation. The outside face of the samples is to face the arcs. Replace lacing before testing.

[h] The number of lacing connections between adjacent pieces (i.e., front/back) on a PFD.

[i] Within 30 s following removal from the cold chamber, the samples are to be dropped using different orientations onto a concrete floor five times from a height of 6 feet (1.8 m). Each sample is then to be manually operated five times and then examined for signs of cracking. The samples are then to be returned to the cold chamber for 15 min. The samples are then to be individually removed and subjected to the Ultimate Breaking Strength Test.

[j] Each flexible or moveable tab of polymeric part is to be mechanically operated 5000 cycles at a rate of 1 cycle/s. The tab is to be completely engaged/disengaged. Also, for hardware which is designed to separate into two parts (i.e., buckles), the parts are to be completely engaged/disengaged. In addition, the samples are to be manually operated 5 times prior to the Ultimate Breaking Strength Test.

[k] *Deleted*

[l] For metallic hardware, only exposures 1 and 8 are applicable.

20.4 Marking

20.4.1 Each shipping carton label for all devices shall be permanently and clearly marked in a color which contrasts with the color of the surface on which the markings are applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) Model number;

c) Lot Number; and

d) Use Code(s).

20.4.2 Each singular polymeric hardware device (i.e., one physical piece such as a slide) shall be permanently marked with the following:

a) Manufacturer's name, tradename, or symbol; and

b) Model number.

20.4.3 Each part of a multi-part polymeric hardware device shall be packaged together and marked with the information specified in 20.4.2 (a – b).

Exception: Parts of a multi-part polymeric hardware device which have less than 0.25 square inches (161.3 mm^2) of surface area on each face, are not required to comply when at least one part is marked.

21 Sailboard Harness Hooks

21.1 General

21.1.1 A sailboard harness hook shall comply with the compliance criteria specified in Table 21.1 when subjected to the test therein.

21.2 Performance

21.2.1 Strength/slippage

21.2.1.1 Each sample independently and after conditioning is to be rigged in its intended manner with appropriately sized webbing in accordance with Table 19.1. The assembly consisting of the hook, spreader bar and webbing is to be fastened to a test form. See Figure 21.1. The webbing is to be fully adjusted to form a snug fit on the test form in order to position the hook in its intended use position. For friction type adjusters the webbing is to be marked at the sample to allow for measurement of the slippage after the test. The hook is then to be attached to a cable actuated by a winch. A weight is to be attached to the test form so that the required test load is applied to the assembly 90 degrees relative to the base of the hook. See Figure 21.2. A total test load of 300 pounds (13.6 kg), which includes the weight, its attachment means and the weight of the test form, is then to be raised from the floor and held in this position for 5 min.

21.2.1.2 The strength test is to be conducted 30 min after completion of the high temperature exposure and 70 h immersion conditionings and immediately after the drop test which follows the low temperature exposure conditioning.

Table 21.1
Sailboard harness components

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use codes[c]	Compliance criteria pounds-force (N)
Strength/Slippage	**1.** SC **2.** Xe_{500} **3.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water **4.** 70 ±2°C (158 ±4°F) for 7 days **5.** -30 ±2°C (-22 ±4°F) **6.** 720 h of Salt Spray as specified in ASTM B117-94[e]	See 21.2.1.1 and 21.2.1.2	5 for each separate conditioning	5SB	For each conditioning, each sample shall support 300 pounds (136 kg) for 5 min without breaking, permanent distortion, impairment of operability, or slippage greater than 1 inch (25.4 mm).
Breaking Strength Test (Hooks)	SC	See 21.2.2.1	5		Average ≥ 350 pounds (159 kg).
Sharp Edge & Projections	SC	UL 1439	1		Shall not be so sharp as to increase the risk of injury to persons.
Hook Disengagement	**1.** SC **2.** Water soak for 2 min	See 21.2.3.1 and 21.2.4.2	5 for each separate exposure		Shall not snag or entangle the rope for exposures 1 and 2.

[a] See Table 2.2 for conditioning details. Also, see Table 19.2.

[b] Color dependent. See 2.4.

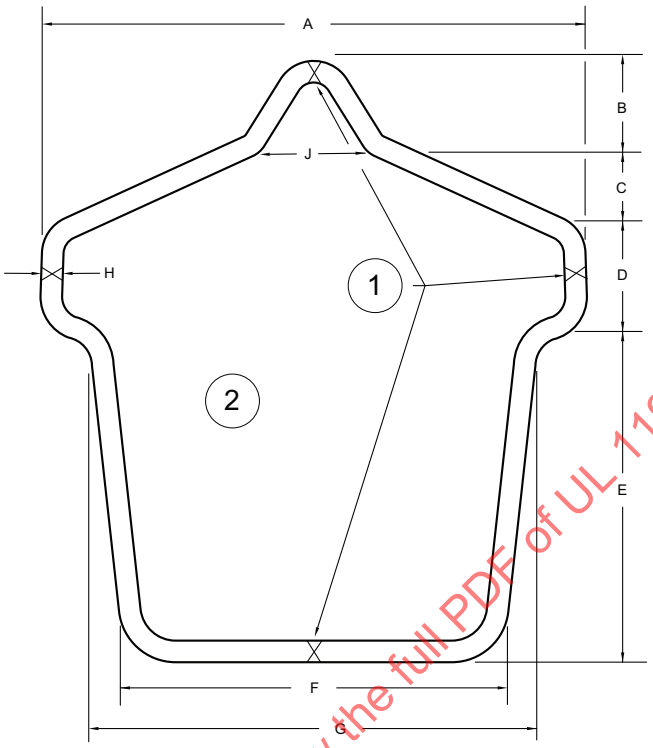
[c] For polymeric hardware, at least 40 pieces. For metallic hardware, at least 25 pieces.

[d] See Table 2.1 for an explanation of Use Code designations.

[e] Metallic hardware only. Not applicable to certified AISI 300 or 400 series stainless steel or equivalent corrosion resistant metal.

Figure 21.1

Strength test form



Size	Dimensions – Inches (mm)								
	A	B	C	D	E	F	G	H	J
Adult	24 (610)	4-1/2 (114)	3 (76.2)	5 (127)	15 (381)	17 (432)	20 (508)	1 (25.4)	7 (178)

NOTES

1 Fabricated from mild-steel rod. (Diameter – Dimension H).

2 Welds and burrs smoothly ground.

3 Primed and painted thoroughly.

4 Buoyant material insert is to be vinyl coated polyvinyl chloride foam, 5 inches (127 mm) thick and shaped to fill the inside of the metal frame.

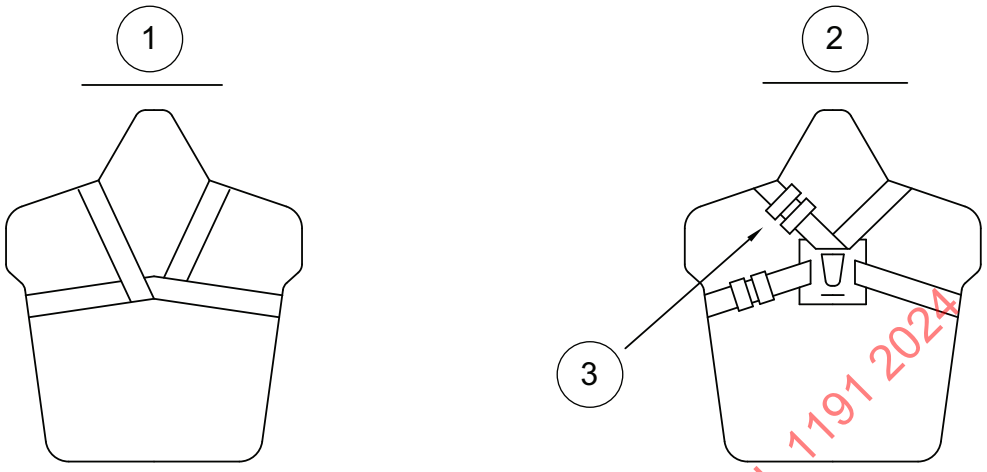
Key

1 – Weld

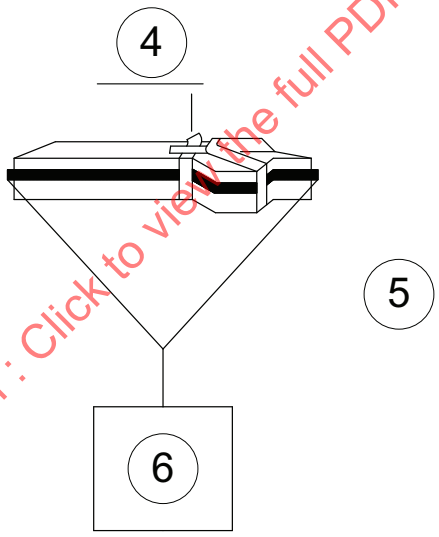
2 – Inset of Buoyant Material

Figure 21.2

Securement of harness hook system to test form



sm446a



sm447b

Key

1 – Back View

2 – Front View

3 – Buckles used to adjust webbing to a secure fit.

4 – Side View (under test)

5 – Hook opening faced towards bottom of frame for all strength tests

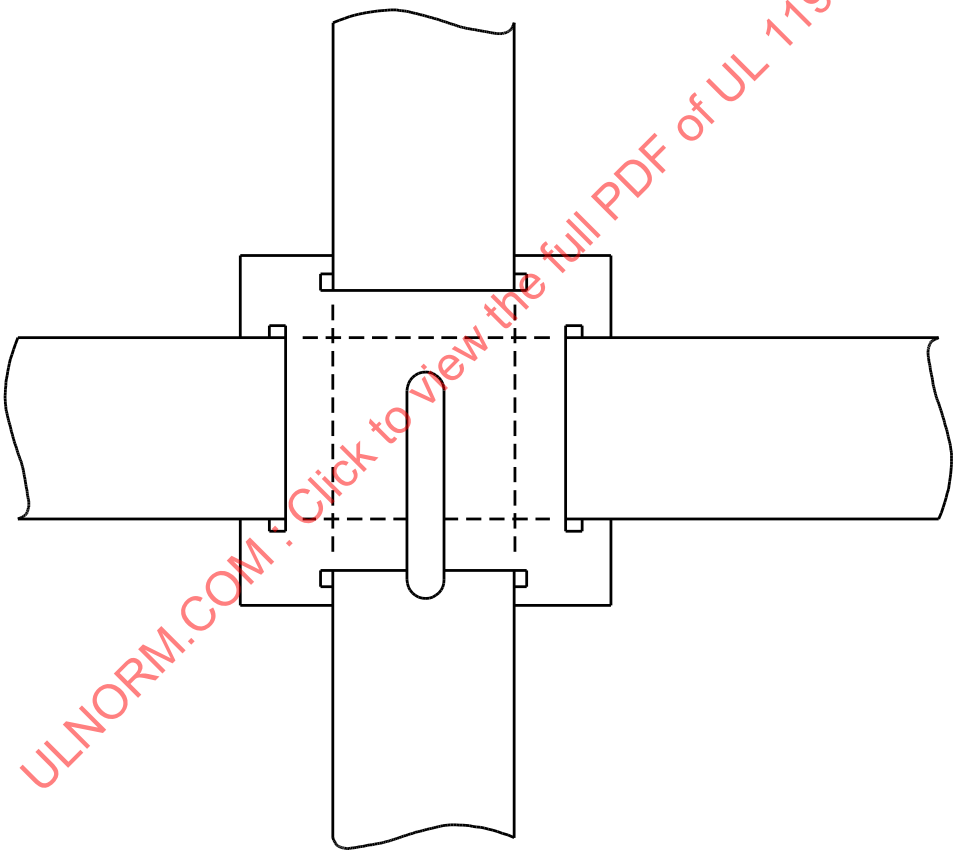
6 – 300 lbs. total test load

21.2.2 Breaking strength

21.2.2.1 For this test, each sample is to be threaded with two lengths of appropriately sized webbing in accordance with Table 19.1 (see Figure 21.3). Each length of webbing is to be 30 inches (762 mm) long. A metal ring having a cross-sectional diameter of 3/8 inch (9.5 mm) is to be attached to the hook. The ring is to be secured to the upper grips of a tension machine. The four webbing ends are to be secured to the lower grips of a tension machine. The base of the hook is to be horizontal at the start of this test so that the initial application of tension is applied 90 degrees relative to the base of the hook. The distance from the bottom of the base of the hook to the top of the lower grip of the tension machine is to be 10 ±1/8 inch (254 ±3 mm). See Figure 21.4. The grips are to be separated at a rate of 12 inches (305 mm) per min and the load at rupture is to be recorded in pounds (N).

Figure 21.3

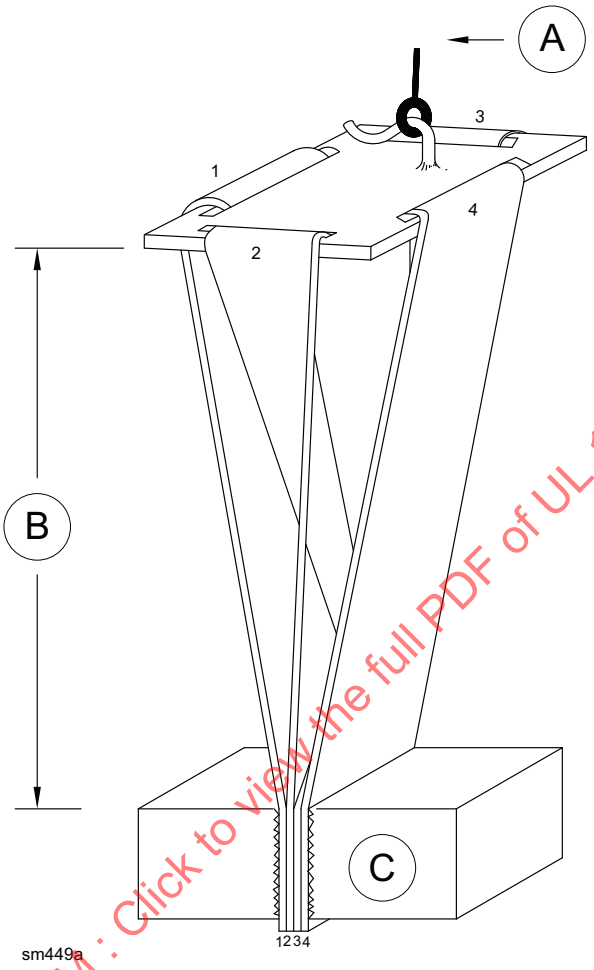
Method for routing webbing for breaking strength test



SM448

Figure 21.4

Breaking strength test set-up



Key

A – Attached to upper grips of tension machine.

B – 10 ±1/8 inch

C – Lower grips of tension machine.

21.2.3 Hook engagement

21.2.3.1 This test is to be conducted prior to the strength tests and following each strength test to determine distortion of the hook. For each sample an aluminum bar of 0.75 inch (19 mm) diameter is to be moved into the space between the hook and hook body in an attempt to penetrate this opening. A nominal force (5 to 10 pounds-force) is to be applied.

21.2.4 Hook disengagement

21.2.4.1 A 3/8 inch (9.5 mm) diameter braided nylon rope 2 feet (610 mm) long is to be fastened to a horizontal bar with the ends of the rope 18 inches (457 mm) apart. The center of the sailboard harness hook, with opening facing down, is to be positioned at the same height as the bar and attached to the longitudinal center of the rope. The rope is to be placed inside the hook and the hook is to be moved in a direction away from the bar in the same horizontal plane as the bar, and at right angles to the bar, until enough tension is transmitted on the rope to prevent the rope from slipping out of the hook. The hook is then to be moved in a direction toward the bar to relieve the tension on the rope.

21.2.4.2 This test is to be conducted dry and then repeated after the rope specified in 21.2.4.1 has been immersed in water for two min.

21.3 Marking

21.3.1 Each shipping carton label for all devices shall be permanently and clearly marked in a color which contrasts with the color of the surface on which the markings are applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) Model number;

c) Lot Number; and

d) Use Code(s).

21.3.2 Each sail board harness hook (i.e., one physical piece such as a slide) shall be permanently marked with the following:

a) Manufacturer's name, tradename, or symbol; and

b) Model number.

22 Multi-Eyelet Guides

22.1 General

22.1.1 A multi-eyelet guide for use with lacing shall comply with the compliance criteria specified in Table 22.1 when subjected to the tests therein.

22.2 Performance

22.2.1 Breaking strength

22.2.1.1 Each sample is to be cut into test specimens one inch (25.4 mm) wide with one lacing loop centered. Each sample is to be independently mounted in a constant rate-of-traverse tension machine. The flat side of the sample is to be clamped in one jaw and lacing is to be passed through the loop of the sample. Each end of the lacing is to be clamped in the other jaw of the tension machine. The initial jaw

separation is to be four to six inches (102 to 152 mm). The jaws are to be separated at a rate of three inches (76 mm) per min and the load, in pounds (N) at rupture is to be recorded.

22.2.2 Cold flexibility test

22.2.2.1 Immediately upon removal from the cold chamber, each sample specimen is to independently be bent both lengthwise and widthwise around a 1 inch (25.4 mm) mandrel until each end touches. The mandrel is to be in the cold chamber with the samples during the exposure.

22.3 Marking

22.3.1 Each shipping carton label for all devices shall be permanently and clearly marked in a color which contrasts with the color of the surface on which the markings are applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) Model number;

c) Lot Number; and

d) Use Code(s).

22.3.2 Each multi-eyelet guide (i.e., one physical piece such as a slide) shall be permanently marked with the following:

a) Manufacturer's name, tradename, or symbol; and

b) Model number.

Table 22.1
Multi-eyelet guides

Tests	Exposure[a]	Test method	Number of samples[b]	Use codes[c]	Compliance criteria pounds-force (N)
Breaking Strength	**1.** SC **2.** Xe_{500} **3.** 70 h immersion in ASTM Ref. Fuel B **4.** 70 h immersion in IRM 902 (Calumet Oil No. 2) **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water **6.** 720 h of Salt Spray as specified in ASTM B117-94[d]	See 22.2.1.1	5 for each conditioning	All except 1, 1F, 2F, 3F, and 5H	Average ≥ 100 (444)
Cold Flexibility	-30 ±2°C (-22 ±4°F) 24 h	See 22.2.2.1	5	All except 1, 1F, 2F, 3F, and 5H	Each sample shall not break or be permanently distorted.

[a] See Table 2.2 for conditioning details. Also, see Table 20.1.

[b] Color dependent. See 2.4.

[c] See Table 2.1 for an explanation of the Use Code designations

[d] Metallic hardware only. Not applicable to certified AISI 300 or 400 series stainless steel or equivalent corrosion resistant metal.

FOAM FLOTATION MATERIAL

23 General

23.1 The properties of foam flotation material are to be investigated in accordance with Table 23.1 and Foam Flotation Material – Performance, Section 24, and shall comply with the compliance criteria specified therein.

23.2 Except where otherwise noted, samples of foam flotation material are to measure 305 mm by 305 mm (12 inches by 12 inches) by the thickness of the material being investigated. When a material is 16 mm (0.625 inch) thick or less, the material is to be plied to the number of layers that provides samples closest to 25 mm (1 inch) in thickness. The condition of the material is to be representative of that intended for the end-product (for example, with or without skin).

23.3 For the purposes of these requirements, skin is a dense outer layer of the foam flotation material. Tests conducted on foam flotation material without skin are representative of the same foam flotation material with skin.

23.4 The samples required for the tests specified in Foam Flotation Material – Performance, Section 24 are to be provided in three batches consisting of six samples per batch.

Table 23.1
Investigation of foam flotation material

Property to be investigated	Minimum number of samples	Test method	Use codes[a]	Compliance criteria
Buoyancy Retention factors:[d] V-factor (For wearable devices)	18[d]	24.3.1.1 – 24.3.3.4	2, 3, 5SB, and 5R.	Minimum 85V[i]
	9[d,e]		1, 1F, 2F, 3F, 5H, and 5WV.	Minimum 94V[j]
C-factor (For cushions)	9[d,e]		4	Minimum 94C
Tensile Strength	10[f]	24.4.1 – 24.4.6	All [k]	Average ≥ 20 lbf/inch^2 (14 N/cm^2).
Oil Resistance	10[f]	24.5.1 – 24.5.3	All [k]	There shall be no visible volume change, softening, nor deterioration of a material when compared with unconditioned specimens, and the average tensile strength of the material shall be not less than 75 percent of the value determined for the unconditioned specimens.
Flexibility	3[f]	24.6.1 – 24.6.3	All [k]	There shall be no cracking.
Compression Deflection	3[g]	24.7.1 – 24.7.3	All [k]	The force required to deflect the material to 75 percent of the material's thickness shall be at least 1 psi (6895 Pa).
Thickness	4[h]	24.9.2	All [k]	The average thickness shall be within ±10 percent of the design values.

[a] The use of foam buoyant material is dependent on (and not limited to) the thickness, buoyancy retention factor, the Type of personal flotation device for which it is intended, and how it is enclosed in a personal flotation device. Therefore, Use Code designations to be assigned accordingly.

Table 23.1 Continued on Next Page

Table 23.1 Continued

Property to be investigated	Minimum number of samples	Test method	Use codes[a]	Compliance criteria
[b] *Deleted* [c] *Deleted* [d] This property shall be investigated for each nominal thickness in which the foam flotation material is produced, except that for material produced in thicknesses greater than 25 mm (1 inch), a plot of property values versus thickness based upon at least three thicknesses (thinnest, midrange, and thickest) of 25 mm (1 inch) and greater are used to obtain values for intermediate thicknesses. [e] Three samples from each of the three lots (batches) of foam flotation material are to be used. [f] Samples from one or more lots (batches). [g] One sample from each lot (batch). [h] Two samples from Batch 1 and one sample each from Batches 2 and 3. [i] 80 V when at least 85 percent of the regulatory minimum buoyancy for the device is supplied by foam having a V-factor of 85 or more. [j] 80 V for Use Code 5WV when at least 85 percent of the regulatory minimum buoyancy for the device is supplied by foam having a V-factor of 94 or more. [k] Use Codes: 1, 1F 2, 2F, 3, 3F, 4, 5H, 5SB, 5R, and 5WV.				

24 Performance

24.1 Density

24.1.1 The weight (W) of each individual sample is to be determined by using an analytical balance with an accuracy of ±0.5 grams (±0.01 ounces).

24.1.2 The samples are then to be immersed to a depth of 50 mm (2 inch) in fresh water at room temperature for 24 h.

24.1.3 The initial volume of each sample is to be determined immediately after the water soak specified in 24.1.2 by:

a) Measuring and recording the initial water level (W_i) with a manometer to the nearest hundredth of an inch;

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

c) Measuring and recording the final water level (W_f) to the nearest hundredth of an inch;

The volume (V) of the foam flotation material is then to be calculated by multiplying the difference between the water levels ($W_f - W_i$) by the cross-sectional area (A) of the rigid container

$$V = (W_f - W_i) \times A$$

where:

V is the Volume of an individual sample (cubic inches);

W_f is the Final Water level of manometer container (inches);

W_i is the Initial Water level of manometer container (inches); and

A is the cross sectional Area of the container (i.e., L x W).

24.1.4 The density (D) is then to be determined by the following equation:

$$D = \frac{W}{V} \times 3.81$$

where:

D is the Density of an individual sample in pounds per cubic foot (kg/m^3 x 0.0623);

W is the Weight of an individual sample determined in accordance with 24.1.1 in grams (ounces); and

V is the Volume of an individual sample (inches^3). Multiply by 3.81 to obtain pounds per cubic foot.

24.2 Specific buoyancy

24.2.1 The Corrected Initial Buoyancy (B_c) of each sample is to be determined, after 24 h of water immersion under 51 mm (2 inches) of fresh water at room temperature by:

a) Weighing the sample to the nearest gram while completely submerged underwater;

b) Reading the individual buoyancy to the nearest gram directly from the digital readout; and

c) Correcting the results to an atmospheric pressure of 760 mm (29.9 inches) Hg and a water temperature of 20°C (68°F), as follows:

$$B_c = MB_i \times \left(\frac{P}{14.7\,psi}\right) \times \left(\frac{527.69°R}{T + 459.69}\right)$$

where:

B_c is the Corrected Initial Buoyancy;

B_I is the Initial Buoyancy in pounds force;

P is atmospheric Pressure in psi; and

T is the Temperature in °F.

24.2.2 The initial specific buoyancy value (SB_i) of each sample specified in Table 23.1 is to be individually computed in accordance with the following formula:

$$SB_i = \frac{B_i}{V}$$

where:

SB_i is the Initial Specific Buoyancy in pounds per cubic foot (kg/m^3 x 0.0623);

B_i is the Corrected Initial Buoyancy in pounds-force (determined in accordance with 24.2.1); and

V is the Volume of an individual sample in cubic feet (determined in accordance with 24.1.3);

The average of the specific buoyancy values is then to be determined and used in the calculation of the buoyancy number (see 24.2.1).

24.3 Buoyancy retention factors

24.3.1 General

24.3.1.1 The buoyancy retention factors (V-factor for wearable devices and C-factor for cushions) of foam flotation material are to be determined following the conditioning specified in 24.3.2.1. The buoyancy retention factors shall comply with the compliance criteria specified in Table 23.1.

24.3.2 Conditioning

24.3.2.1 Prior to the tests specified in Table 23.1 for buoyancy retention factors, the samples are to be subjected to the following sequential conditioning:

a) Initial Storage – The samples are to be individually stored on racks for 120 h at 23 ±2°C (73 ±4°F).

b) Initial Immersion – See 24.1.2, followed by the initial buoyancy measurement specified in 24.2.2(a).

c) Heat Conditioning – The samples are to be conditioned for 120 h in an air-circulating oven at a temperature of 60 ±2°C (140 ±5°F). A spacing of at least 25 mm (1 inch) is to be maintained between the samples.

d) Cool-Down – Immediately after removal from the oven, the samples are to be immersed to a depth of 50 mm (2 inch) in fresh water at a temperature of 23 ±2°C (73 ±4°F) for 15 min.

e) V-factor Compression – Immediately after removal from the water, one-half of the samples are to be subjected to a load of 115 kg (252 pounds) as described in Compression Application, (g) [see (f)].

f) C-factor Compression – Immediately after removal from the water, the remaining samples from (e), are to be subjected to a load of 229 kg (504 pounds) as described in Compression Application, (g).

g) Compression Application – Each individual sample is to be placed on top of a flat, rigid surface that extends at least 25 mm (1 inch) beyond the sample on all sides. The specified loads for V-factor and C-factor testing, [see (e) and (f)], are to be uniformly applied to the top of the sample for 24 h. The ambient temperature is to be 23 ±2°C (73 ±4°F) during the compression application. As previously stated, each individual sample is to be placed between two flat, rigid surfaces that extend at least 25 mm (1 inch) beyond the sample on all sides. This arrangement is capable of accommodating up to nine samples with the applicable load applied to the stack. When a material is 16 mm (0.625 inch) thick or less, see 23.2.

h) Intermediate Immersion – The samples subjected to the 227-kg (504 pound) compression specified in item (f) are to be immersed to a depth of 51 mm (2 inch) in fresh water at 23 ±2°C (73 ±4°F) for 24 h, immediately after removal of the load.

i) Recovery Storage – All the samples are to be stored on racks at 23 ±2°C (73 ±4°F). The samples subjected to the 113-kg (252-pound) compression specified in (e) are to be stored for 264 h, and the samples subjected to the 227-kg (504-pound) compression specified in (f) are to be stored for 240 h. A spacing of at least 25 mm (1 inch) is to be maintained between the samples.

k) Final Immersion – The samples are then to be immersed to a depth of 51 mm (2 inch) in fresh water at room temperature for 24 h.

24.3.3 Calculations

24.3.3.1 Immediately after the conditioning specified in 24.3.2.1, the final buoyancy (B_f) of each sample is to be determined by:

a) Weighing the sample to the nearest gram while completely submerged underwater; and

b) Reading the individual buoyancy to the nearest gram directly from the digital readout.

24.3.3.2 The V-factor for the foam flotation material, as determined from the buoyancies of individual samples subjected to the 113-kg (252-pound) -compression specified in 24.3.2.1(e), is to be calculated using the following equation and rounding-off the value obtained to the nearest whole number:

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

where:

B_f is the Final Buoyancy of an individual sample, as determined in accordance with 24.3.3.1;

B_i is the Initial Buoyancy of an individual sample, as determined in accordance with 24.2.2; and

N is the Number of samples subjected to the compression.

24.3.3.3 The C-factor for the foam flotation material, as determined from the buoyancies of individual samples subjected to the 227-kg (504-pound) compression specified in 24.3.2.1(f), is to be calculated using the following equation and rounding-off to the nearest whole number:

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

where:

B_f is the Final Buoyancy of an individual sample, as determined in accordance with 24.3.3.1;

B_i is the Initial Buoyancy of an individual sample, as determined in accordance with 24.2.2; and

N is the Number of samples subjected to the compression.

24.3.3.4 The V-factor assigned to a given thickness of a unique formulation of foam flotation material shall be either the value calculated in accordance with 24.3.3.2 or the lowest V-factor of all greater thicknesses of the same formulation, whichever is lower. The C-factor assigned to a given thickness of a unique formulation of foam flotation material shall be either the value calculated in accordance with 24.3.3.3 or the lowest C-factor of all greater thicknesses of the same formulation, whichever is lower.

24.4 Tensile strength

24.4.1 After being tested as described in 24.4.2 – 24.4.6, the average tensile strength of the samples specified in Table 23.1 shall comply with the compliance criteria specified in Table 23.1 (see 24.4.5).

24.4.2 Prior to the test, the dumbbell-shaped specimens specified in 24.4.3 are to be conditioned in air at 23 ±2°C (73 ±4°F) and 50 ±5 percent relative humidity for 40 h.

24.4.3 Dumbbell-shaped specimens are to be cut from the samples using Die A as specified in the Standard Test Methods for Rubber Properties in Tension, ASTM D412. Specimens from five of the samples are to be cut parallel to each other, and specimens from the other five samples are to be cut parallel to each other and in the direction perpendicular to that in which the specimens from the first five samples were cut. The top and bottom surfaces of the specimens are to be parallel, and the cut surfaces are to be perpendicular to the top surface and free from sharp or ragged edges. Any surface skin or irregularities that affects the test results are to be removed by light buffing. When the material is more than 13 mm (0.5 inch) thick, the samples are to be prepared to a thickness of 13 mm (0.5 inch) or less.

24.4.4 The cross-sectional area (A) of the dumbbell-shaped specimens specified in 24.4.3 is to be calculated as follows:

$$A = T \times W$$

where:

A is the cross-sectional Area of the specimen;

T is the average of three Thickness measurements taken on the narrow section of the cut specimen; and

W is the Width of the specimen measured at the narrow section.

24.4.5 The tensile strength for the dumbbell-shaped specimens is to be determined in accordance with the method described in 24.4.6 and calculated as follows:

$$Tensile\ Strength = \frac{L}{A}$$

where:

L is the Load in pounds-force (N) required to rupture the sample (see 24.4.6); and

A is the cross-sectional Area of the specimen determined in accordance with 24.4.4.

24.4.6 Each dumbbell-shaped specimen specified in 24.4.4 is to be individually clamped in the jaws of a tension machine and separated at a rate of 0.5 meter per min (20 inches per min). The value at the time of rupture is to be recorded.

24.5 Oil resistance

24.5.1 After being tested as described in 24.5.2 and 24.5.3, dumbbell-shaped specimens shall comply with the compliance criteria specified in Table 23.1.

24.5.2 Specimens are to be prepared as specified in 24.4.3.

24.5.3 The dumbbell-shaped specimens are to be completely immersed for 70 h in ASTM Reference Oil No. 2 at 23 ±2°C (73 ±4°F). Upon removal, the specimens are to be blotted with filter paper and compared with unconditioned specimens of the same dimensions for evidence of volume change, softening, or deterioration. The specimens are to stand for 30 min at 23 ±2°C (73 ±4°F). The specimens then are to be subjected to the Tensile Strength Test described in 24.4.1 – 24.4.6.

24.6 Flexibility

24.6.1 After being tested as described in 24.6.3, the samples specified in 24.6.2 shall comply with the acceptance criteria specified in Table 23.1.

24.6.2 Samples are to be 25 mm by 203 mm (1 inch by 9 inches) by the thickness of the foam flotation material being investigated.

24.6.3 Prior to the test, the samples specified in 24.6.2 are to be conditioned for 4 h in air at minus 18 ±1°C (0 ±2°F). While at the same temperature, the longest dimension of the sample is to be wrapped 180 degrees around a steel mandrel within 5 s of the removal from the freezer. The mandrel is to have a diameter equal to two times the thickness of the foam flotation material under investigation.

24.7 Compression deflection

24.7.1 After being tested as described in 24.7.2 and 24.7.3, the samples specified in Table 23.1 shall comply with the compliance criteria specified therein.

24.7.2 Each sample is to be compressed to 75 percent of its original thickness using the compression machine specified in 24.7.3. The force required to compress the sample to this thickness is to be recorded in N/m^2 (pounds/$inch^2$).

24.7.3 An apparatus shall be provided having a flat compression foot, larger than the specimen to be tested, connected to a force-measuring device and mounted in a manner such that the product or specimen can be deflected (compressed) at a speed of 0.2 to 0.85 mm/s (0.5 to 2.0 in/min). The apparatus shall be arranged to support the specimen on the level horizontal plate.

24.7.4 Each sample is to be square, measuring 101 by 101 ±3 mm (4 by 4 ±1/8 in).

24.7.5 Place the specimen centered in the line of the axial load on the supporting plate of the apparatus.

24.7.6 Bring the compression foot into contact with the specimen exerting a force of 4.45 N (1 lbf) and determine thickness. Compress the specimen 25 ±0.5 percent of this thickness within the speeds stated in 24.7.3 and take the reading of the load immediately.

24.7.7 Calculate the 25 percent compress deflection pressure, express in kPa (lbf/in^2) as follows:

$$CD = \frac{F}{A}$$

where:

CD is the Compression Deflection pressure, kPa (psi);

F is the Force required to compress the specimen 25 percent of the thickness, kN (lbf); and

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

24.8 Dimensional analysis

24.8.1 *Deleted*

24.9 Thickness

24.9.1 After being examined as described in 24.9.2, the samples specified in Table 23.1 shall comply with the compliance criteria specified therein.

24.9.2 A dial indicator measuring instrument with a circular presser foot area of 25 mm^2 (1 $inch^2$) which exerts a pressure of 28 grams (1 ounce) is to be used for measuring the thickness of the samples. The indicator is to have a measuring accuracy ±0.001 inch. Nine thickness measurements are to be made on each sample, and the average is to be computed for each sample. The average of the four samples is then to be calculated.

25 Marking

25.1 Each shipping label, shipping carton, or container shall be permanently and clearly marked in a color that contrasts with the color of the surface on which the markings are applied with the following:

a) Manufacturer's name, tradename, or symbol;

b) The nominal thickness of the material in inches or mm (for example, 1/2 inch, 13 mm, or 1/2");

c) The lot number;

d) Model or style; and

e) Use Codes.

POLYMERIC ENCLOSURES FOR KAPOK

26 Performance

26.1 General

26.1.1 Polymeric enclosures for kapok shall comply with the requirements in Table 26.1 and Table 26.2 when subjected to the tests therein.

Table 26.1
Polymeric enclosures for kapok

Tests	Exposure[a]	Test methods	Number of samples[b]	Use codes[c]	Compliance criteria pounds-force (N)
Tensile Strength & Ultimate Elongation	**1.** SC **2.** 70 ±2°C (158 ±4°F) for 7 days (168 h)	ASTM D412 Method A Dumbell Die A	5 for each direction for each conditioning	All[d]	See Table 26.2
Tear Resistance	**1.** SC **2.** 70 ±2°C (158 ±4°F) for 7 days (168 h)	ASTM D1004-94	5 for each direction for each conditioning	All[d]	See Table 26.2
Air Leakage	SC	See 26.2.1 & 26.2.2	10	All[d]	There shall be no leakage after being subjected to 2 psi (13.8 kpa) of air for 5 min.
Cold Cracking	-18 ±1°C (0 ±2°F) for 1 h	See 26.3.1 – 26.3.5	10	All[d]	There shall not be more than 2 samples that break into two or

Table 26.1 Continued on Next Page

Table 26.1 Continued

Tests	Exposure[a]	Test methods	Number of samples[b]	Use codes[c]	Compliance criteria pounds-force (N)
					more pieces as a result of the test.

[a] See Table 2.2 for exposure details.

[b] A minimum of 15 foot^2 (1.4 m^2).

[c] See Table 2.1 for explanation of Use Code designations.

[d] Applies to Use Codes 1, 2, 3, 4BC, 4H, 5H, and 5R.

Table 26.2
Compliance criteria for tensile strength, ultimate elongation, and tear resistance of polymeric enclosures for kapok

Property investigated	Minimum test values in pounds-force (N)[a]	
	For PFD Type IV (use code 4BC and 4H)	
	Column A	Column B
Tensile Strength	9.2 (41)	6.4 (28)
Ultimate Elongation (in percent)	200%	225%
Ultimate Elongation (Transverse direction)	200%	250%
Tear Resistance	1.76 (8)	1.76 (8)
	For PFD Type I/Level 150 & Type V (use codes 1 and 5H)	
	Column A	Column B
Tensile Strength	6.9 (31)	6.4 (28)
Ultimate Elongation (in percent)	150%	225%
Ultimate Elongation (Transverse direction)	200%	250%
Tear Resistance	1.06 (4.7)	1.76 (8)
	For PFD Type II/Level 100, Type III/Level 70, (use codes 2, 3, and 5R)	
	Column A	Column B
Tensile Strength	6.9 (31)	4.8 (21)
Ultimate Elongation (in percent)	150%	225%
Ultimate Elongation (Transverse direction)	200%	250%
Tear Resistance	1.06 (4.7)	1.06 (4.7)

[a] Two options are available as specified in Columns A & B and all values of a single vertical column shall be used depending on the PFD type. The values are not interchangeable from Column A to Column B.

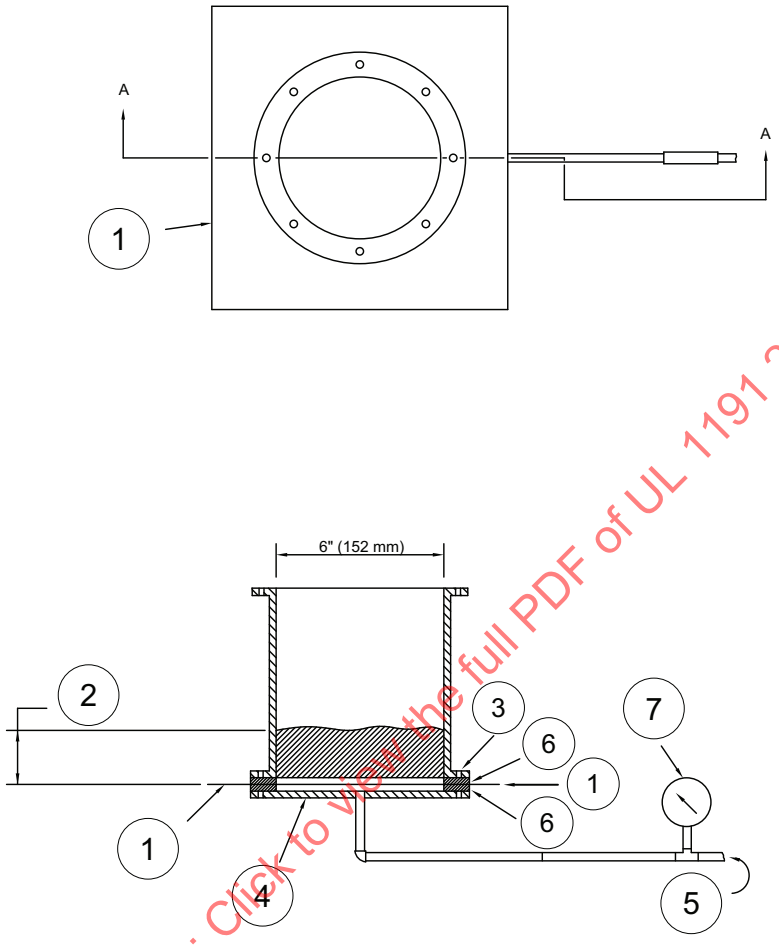
26.2 Air-leakage

26.2.1 The samples used for the test are to have dimensions of 8 by 8 inches (203 by 203 mm).

26.2.2 The samples are to be mounted individually in the apparatus illustrated in Figure 26.1 and subjected to a minimum 2 psig (13.8 kPa) air pressure for 5 min. During the test, each sample is to be covered by at least 1 inch (25.4 mm) of a soapy water solution. While under pressure, the samples are to be examined for leakage as evidenced by air bubbles coming through the enclosure.

Figure 26.1

Apparatus for air leakage test



Key

1 – Film sample

2 – 1 inch (25 mm) minimum

3 – Flange

4 – Bottom Plate

5 – Air supply

6 – Gasket

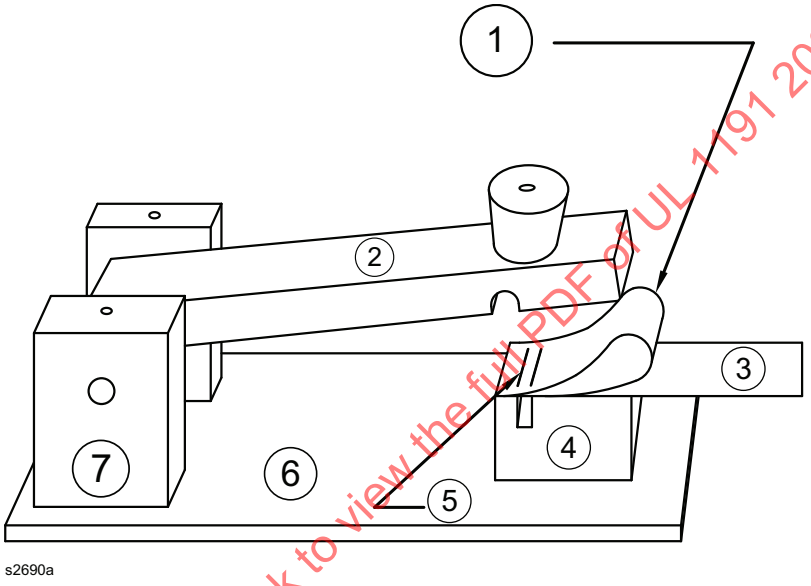
7 – Gauge

26.3 Cold crack

26.3.1 As illustrated in Figure 26.2, the short ends of each five 2 by 5 3/4 inch (51 by 146 mm) samples are to be laid one atop the other and their edges are to be placed on an underlying 2 by 5 inch (51 by 127 mm) stiff, paper card (standard index-file card stock). The sample is to loop naturally without creases or folds and is to be carefully stapled to the card twice with the staples close together and both parallel to and 1/2 inch (12 mm) from the 2 inch (51 mm) edges.

Figure 26.2

Placement of sample and arm



Key

1 – Specimen looped naturally (no creases or folds)

2 – Arm

3 – Card

4 – Anvil

5 – Two staples

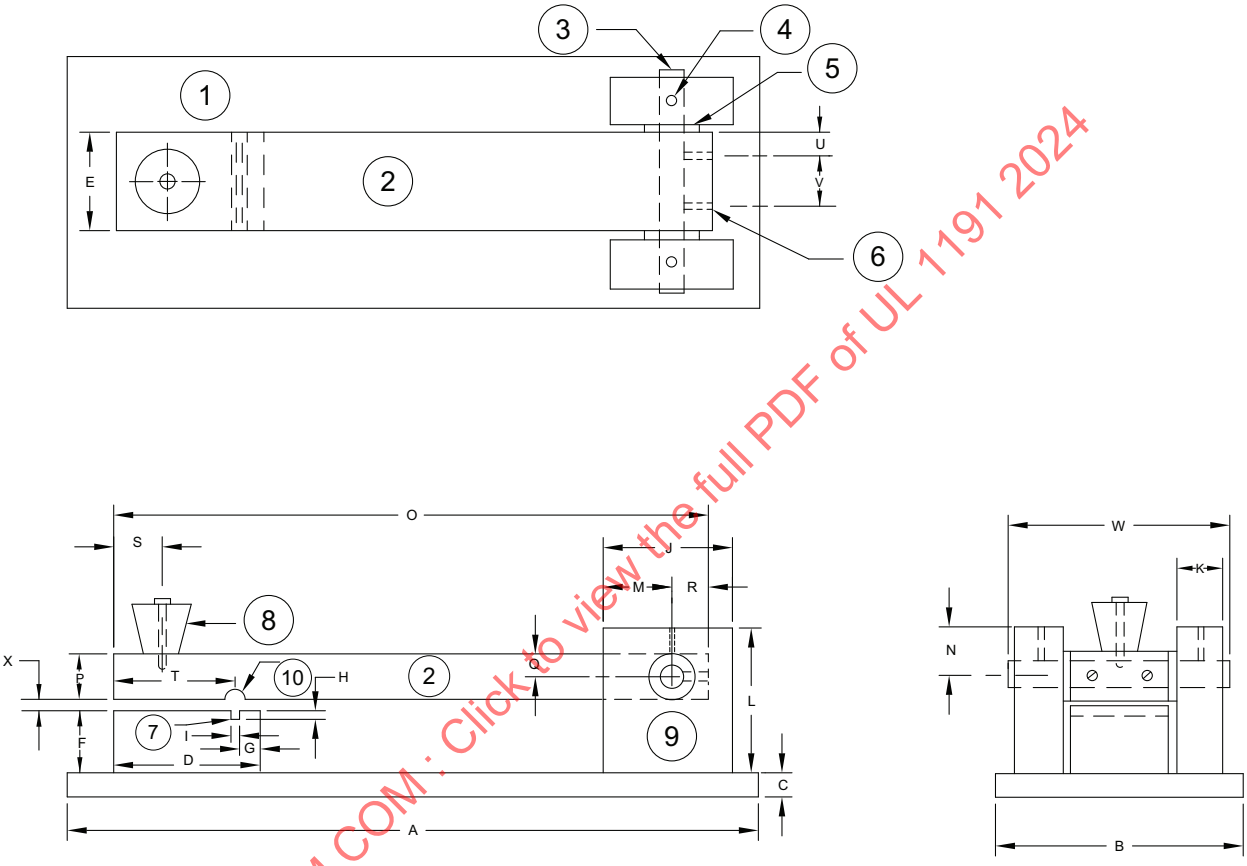
6 – Base

7 – Arm support

26.3.2 With the arm rotated 180 degrees from the anvil, the impacting device illustrated in Figure 26.3 (see Table 26.3 for the dimensions) is to be cooled to a temperature of minus 18 ±1°C (0 ±2°F) in a shallow refrigerator compartment having a square level floor 18 inches (457 mm) or more on a side and opening from the top.

Figure 26.3

Impacting device



s2691a

Key

1 – Base

2 – Arm

3 – Shaft fits loosely

4 – Countersunk oil hole

5 – Machined washer

6 – Tap for setscrew

7 – Slot

8 – Rubber stopper

9 – Arm support

10 – Groove

Table 26.3
Dimensions of impact device

	Dimensions			
Part	**Name**	**Identification letter on drawing**	**Inches**	**Millimeters**
Base	length	A	14	356
	width	B	5	127
	thickness	C	1/2	13
Anvil – bolted to base with machine screws (not shown)	length	D	3	76
	width	E	2	51
	height	F	1-7/16	37
	slot location	G	7/16	11
	slot depth	H	1/4	6
	slot width	I	1/8	3
Two arm supports – bolted to base with machine screws (not shown)	length	J	3	76
	thickness	K	1	25
	height	L	3	76
	diameter of oil holes	none	1/8	3
	oil-hole and shaft-hole centerline	M	1-1/2	38
	shaft-hole centerline	N	1/2	13
	diameter of shaft hole	none	slightly greater than 1/2	slightly greater than 13
Arm	length	O	12	305
	width	E	2	51
	thickness	P	1	25
	diameter of shaft hole	none	slightly greater than 1/2	slightly greater than 13
	shaft-hole centerline	Q	1/2	13
	shaft-hole centerline	R	1	25
	stopper-hole	S	1	25
	centerline	T	2-1/2	64
	groove centerline	none	1/4	6
	setscrew centerline	U	1/2	13
	centerline separation of setscrews	V	1	25
Two machined washers	outside diameter	none	1	25
	inside diameter	none	slightly greater than 1/2	slightly greater than 13
Shaft	diameter	none	1/2	13
	length	W	4-1/2	114
Separation between anvil and arm		X	1/16	1.6

26.3.3 All ten samples are to be placed on the floor of the cold chamber with their loops up and without being touched by the hands of the tester (the card is to be used for a handle), one another, or anything else, and is to cool for 1 h. Then, while the samples and the impacting device remain in the cold chamber, one of the samples is to be placed loop-up on the anvil of the impacting device with the staples in the slot as illustrated in Figure 26.2. Care is to be taken so that the sample does not touch anything during this

process. The arm of the impacting device is to be raised from the 180 degree position to a position in which the impacting face of the arm is at an angle of 85 degrees with the horizontal face of the anvil.

26.3.4 By means of a mechanical release, the arm is to be freed so that it falls and strikes the sample. The arm then is to be raised and secured again at the 85 degree position, and the sample is to be removed and examined. A sample does not comply with this requirement when it has broken into two or more pieces.

26.3.5 In as rapid succession as possible (to reduce warming of the samples), each of the nine remaining samples, in turn, is to be placed on the anvil, impacted by the arm (with care being taken that the staples are in the slot), and examined for breakage of the sample.

27 Marking

27.1 Each shipping label shall be clearly and permanently marked in a contrasting color with the following:

a) Manufacturer's name, tradename, or symbol;

b) Style designation; and

c) Lot number.

RF WELDED, URETHANE COATED NYLON COMPARTMENT MATERIALS FOR HYBRID AND FULLY INFLATABLE RECREATIONAL PFDs

28 General

28.1 Woven coated compartment materials for hybrid and fully inflatable PFDs shall comply with the compliance criteria specified in Table 29.1 when subjected to the tests therein.

28.2 Unsupported compartment materials shall be completely enclosed in 1F, 2F, 3F or 5H fabric and shall also comply with the requirements in Table 29.2 when subjected to the tests therein.

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

29 Performance

29.1 Breaking load test

29.1.1 Each sample specified in Table 29.1 shall be tested in accordance to ASTM D5034-90, Method G-E. The dimension of the front jaws for each clamp shall be 1 inch by 1 inch (25 mm by 25 mm) and must be rubber padded to prevent slippage. The dimension of the back jaw for each clamp shall be 1 inch (25 mm) parallel to the application of load by 1 inch (25 mm) or more perpendicular to the application of load. The initial jaw separation must be 3 inches (76 mm) unless specified otherwise. The tensile testing machine shall be operated at a uniform pulling speed of 12 ±0.5 in/min (305 ±13 mm/min). The load cell range shall be capable of providing the maximum load to break (break strength value shall be within 5 percent to 95 percent of full range). The samples shall be placed in the tensile testing machine with the long dimension parallel to the application of load. The samples shall be marked with a line 1-1/2 inches from the left edge that extends throughout the sample following along a single yarn. The sample shall be placed in the tensile testing machine with the marked line along the left edge of the upper and lower jaws to ensure equal yarn extension. The sample shall extend 0.5 inches (12.7 mm) above the top jaw and 0.5 inches (12.7 mm) below the bottom jaw.

Table 29.1
Woven coated compartment materials

Tests	Exposure[a]	Test method	Number of samples[c]	Sample size inches (mm)	Use Codes[f]	Compliance criteria pounds-force (N)
Breaking Load (woven fabrics only)	**1.** SC **2.** After accelerated aging in accordance to ASTM D5427 or 168 h at 158°F (70°C) **3.** After soil burial and fungus resistance in accordance to Method 5762 of AATCC-30 (12 weeks exposure); or After *aspergillius niger* fungus resistance in accordance to ASTM G21[h] **4.** Xe_{750} or Nt_{75}[d]	ASTM D5034-90 Method G-E	5 warp and 5 fill for each separate conditioning	4 x 6 (101 x 152)	1F, 2F, 3F, and 5H	**Exposure 1** Average ≥210 (935) in the warp direction (direction of greater thread count), and Average ≥180 (800) in the fill direction (direction of lesser thread count). **Exposure 2** The sample shall be examined visually and shall show no evidence of blister or other defects that affect the intended use. **Exposures 2 and 3** Average ≥189 (841) in the warp direction; and Average ≥ 162 (721) in the fill direction **Exposure 4** Average ≥ 84 (374) in the warp direction; and Average ≥ 72 (320) in the fill direction
Trapezoid Tear Strength	**1.** SC **2.** After accelerated aging in accordance to ASTM D5427, or 168 h at 158°F (70°C)	Method 5136 of FTMS 191A	5 warp and 5 fill for each separate conditioning	3 x 6 (76 x 152)	1F, 2F, 3F, and 5H	**Exposure 1** Average ≥10 (45) for each direction in the warp direction and 8 (36) in the fill direction. **Exposure 2** Average ≥ 9 (40) in the warp direction; and Average ≥ 7 (32) in the fill direction
Permeability	**1.** SC **2.** After accelerated aging in accordance to ASTM D5427 or 168 h at 158°F (70°C)[g] **3.** After soil burial and fungus resistance in accordance to AATCC-30 (12 weeks exposure); or After *aspergillius niger* fungus resistance in accordance to ASTM G21 **4.** 65 ±1°C (149 ±2°F) at 95 % relative humidity for 360 h in accordance to ASTM D3690-78(1990)[g]	ASTM D1434-82(1992) with CO_2	3 for each separate conditioning	5 x 5 (125 x 125)	1F, 2F, 3F, and 5H	**Exposures 2 – 4** Average ≤110 percent of the value determined following exposure 1.

Table 29.1 Continued on Next Page

Table 29.1 Continued

Tests	Exposure[a]	Test method	Number of samples[c]	Sample size inches (mm)	Use Codes[f]	Compliance criteria pounds-force (N)
Abrasion Resistance (Woven Fabrics)	**1.** SC **2.** After abrasion resistance in accordance to ASTM D4157 using No. 8 cotton duck, 18 ounces per square yard, 6 lbs. tension, 2 lbs. pressure, and 100,000 double rubs	ASTM D5035-90 Method 1C-E	8 warp and 8 fill for each separate conditioning	9 x 1-7/8 (229 x 48)	1F, 2F, 3F, and 5H	Except for a material intended for use under a fabric envelope or otherwise protected, the 8 sample average for each direction shall retain at least 75 percent of that value determined following exposure 1

[a] See Table 2.2 for the sample conditionings.

[b] For fully inflated and packed conditions, only Xe_{750} of weathering is to be conducted for a material not intended to be fully encased within a cover fabric.

[c] Color dependent. See 2.4.

[d] Every color shall be weathered.

[e] The abradant material shall be orientated such that the warp direction is perpendicular to the rotational direction of the abrasion resistance machine.

[f] See Table 2.1 for explanation of Use Code designations.

[g] Optional – In lieu of the Permeability Test for exposures 2 and 4 only, the Buoyancy Test using carbon dioxide as defined in the exception for 29.3 in UL 1180 shall be conducted after the exposures 2 and 4 on the complete device.

[h] This exposure is not required for polyurethane coatings with a weight ≥ 146 g/m^2 (4.35 oz/yd^2).

Table 29.2
Unsupported compartment materials

Tests	Exposure[a]	Test method	Number of samples	Sample size inches (mm)	Use Codes[b]	Compliance criteria
Ultimate Tensile and Elongation	**1.** SC **2.** 70 ±2°C (158 ±4°F) for 7 days (168 h) **3.** After soil burial and fungus resistance in accordance to AATCC-30 (12 weeks exposure); or After *aspergillius niger* fungus resistance in accordance to ASTM G21[d]	ASTM D882	5 for each direction for each conditioning	4 x 0.25 (101.6 x 6.4)	1F, 2F, 3F, and 5H	**Exposure 1** Average ultimate tensile strength ≥3000 psi in each direction and Average ultimate elongation ≥ 15,000 psi in each direction. **Exposures 2 and 3** Average ultimate tensile strength ≥2700 psi in each direction and Average ultimate elongation ≥ 12,150 psi in each direction.
Tear Strength	**1.** SC **2.** 70 ±2°C (158 ±4°F) for 7 days (168 h)	ASTM D1004	5 for each direction for each conditioning	ASTM D1004	1F, 2F, 3F, and 5H	**Exposure 1** Average ≥ 400 psi for each direction **Exposure 2** Average ≥ 360 psi for each direction.
Weight Loss	**1.** SC **2.** Abrasion Resistance in accordance with ASTM D3884 with	See 29.3.1–29.3.2	3 for each separate conditioning	6 x 6 (152 x 152	1F, 2F, 3F, and 5H	**Exposure 2** Average percent weight loss shall not be greater than 0.06 percent of the weight

Table 29.2 Continued on Next Page

Table 29.2 Continued

Tests	Exposure[a]	Test method	Number of samples	Sample size inches (mm)	Use Codes[b]	Compliance criteria
	the following characteristics: a) 1000 cycles; b) CS17 abrasion wheel; and c) 1000 gram load					determined following exposure 1.
Cold Cracking	minus 56 ±4°C (minus 70 ±2°F) for 1 day	See 26.3.1 – 26.3.5	10	See 26.3.1 – 26.3.5	1F, 2F, 3F, and 5H	Each sample shall not break, crack, or separate as a result of the test.
Permeability	**1.** SC **2.** After accelerated aging in accordance to ASTM D5427 or 168 h at 158°F (70°C)[c] **3.** After soil burial and fungus resistance in accordance to AATCC-30 (12 weeks exposure); or After *aspergillius niger* fungus resistance in accordance to ASTM G21 **4.** 65 ±1°C (149 ±2°F) at 95 % relative humidity for 360 h in accordance to ASTM D3690-78(1990)[c]	ASTM D1434-82(1992) with CO_2	3 for each separate conditioning	5 x 5 (125 x 125)	1F, 2F, 3F, and 5H	**Exposures 2 – 4** Average ≤110 percent of the value determined following exposure 1.

[a] See Table 2.2 for the sample conditionings.

[b] See Table 2.1 for explanation of Use Code designations.

[c] Optional – In lieu of the Permeability Test for exposures 2 and 4 only, the Buoyancy Test using carbon dioxide as defined in the exception for 29.3 in UL 1180 shall be conducted after the exposures 2 and 4 on the complete device in the uninflated condition.

[d] This exposure is not required for polyurethane coatings with a weight ≥ 146 g/m^2 (4.35 oz/yd^2).

29.2 Trapezoid tear strength test

29.2.1 Two samples, measuring 3 inches (76.2 mm) wide by 6 inches (152.4 mm) long are to be used. The warp samples shall be cut with the long dimension perpendicular to the warp yarns and the filling samples shall be cut with the long dimension parallel to the warp yarns. No two warp samples shall contain the same warp yarns and no two samples shall contain the same filling yarns. No sample shall include selvage.

29.2.2 An isosceles trapezoid having an altitude of 3 inches (76.2 mm) and bases of 1 inch (25.4 mm) and 4 inches 101.6 mm) respectively, shall be marked on each sample. A cut approximately 3/8 inch (9.5 mm) in length shall be made in the center of and perpendicular to the 1 inch (25.4) base. The specimen shall be clamped in the tensile testing machine along the nonparallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut and the long trapezoid base shall

lie in the folds. Set the nominal gauge length at 1 inch (25.4 mm) and select the capacity of the tester suitable for the specimens to be tested. The maximum load required to tear the specimen must be within the rated operating capacity of the tester. For a CRT machine this should be considered as the range of 15 to 85 percent of the rated capacity. Operate the pulling jaw at 12 ±1/2 inch (304.8 ±12.7 mm) inch per min.

29.3 Weight loss

29.3.1 Three samples, measuring 6 inches (152 mm) wide by 6 inches (152 mm) long are to be used.

29.3.2 Prior to conducting the abrasion resistance, each sample shall be weighed. After the completion of the abrasion resistance, each sample shall be reweighed. The percent weight loss shall be calculated by using the following equation:

$$\%WL = \left[\frac{(W_o - W_t)}{W_o}\right] \times 100$$

Where:

%WL = Percent Weight Loss

W_f = Final Weight

W_o = Original Weight

30 Marking

30.1 Each shipping label shall be clearly and permanently marked in a contrasting color with the following:

a) Manufacturer's name, tradename, or symbol;

b) Style designation;

c) Lot number;

d) Lab dye lot number, color code number, or color formulation; and

e) Use Code(s).

INFLATION SYSTEMS FOR HYBRID AND FULLY INFLATABLE RECREATIONAL PFDs

31 Construction

31.1 General

31.1.1 An exposed edge or projection of an inflation system shall not be so sharp as to damage the material of an inflatable compartment or constitute a risk of injury to persons during intended use. Referee measurements required to determine compliance with this requirement are to be those described in the requirements in the Standard for Tests for Sharpness of Edges on Equipment, UL 1439.

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

31.1.3 An inflation system inflator mechanism shall not be located inside an inflation compartment.

31.1.4 An inflation system that is capable of being converted between any form of automatic inflation and a manual-only mode of inflation shall be designated with a 6F Use Code if it does is not have single point status indication and does not comply with 31.1.5. If the inflation system meets 31.1.5 it will maintain its base design Use Code. The component(s) used for conversion to manual-only inflation, if any, shall provide an obvious distinctive difference to the inflator body or, if intended to be viewed through a window, to what is seen in the window when installed. The conversion component(s) shall be marked with the word “MANUAL”, prominently displayed.

31.1.5 Additionally, an inflation system that is capable of being converted between any form of automatic inflation and a manual-only mode of inflation that is provided with cylinder seal indication, the component(s) used for conversion to manual-only inflation shall be:

a) Obvious to anyone viewing it as specified in 31.7.1(g); and

b) Always easily distinguishable from any form of automatic arming when viewed as specified in 31.7.1(g).

31.1.6 One-time use inflation systems shall be designed so that the inflation cylinder is permanently attached to the inflation system or mechanically bonded using an adhesive such as an epoxy or other means.

31.1.7 An electronic inflation system shall be designed such that electrical system is completely sealed from water ingress and that no live parts are accessible to the user.

31.1.8 The electrical system within an electronic inflation system shall be low-voltage limited energy. The maximum load current, under rated voltage, is to be drawn under any condition of loading, including short circuit, using a resistor. The current is to be measured 60 seconds after the application of the load. The resistor is to be continuously readjusted during this 1 minute period to maintain maximum load current. The calculated energy shall not exceed 100 VA.

31.1.9 The power source within an electronic inflation system shall comply with one of the following:

a) Standard for Lithium Batteries, UL 1642; or

b) Standard for Household and Commercial Batteries, UL 2054.

31.2 Materials

31.2.1 A metallic component of an inflation system shall have salt water and salt air corrosion characteristics equal or superior to 410 stainless steel or perform its intended function and have no visible pitting or other damage on any surface after 720 h of salt spray testing in accordance with ASTM B117-94. Combinations of metals shall be galvanically compatible.

Exception No. 1: An expendable component (for example, a gas cylinder) is not required to be of corrosion-resistant material, when the component is provided with a durable zinc or cadmium plating, or is equivalently protected against corrosion.

Exception No. 2: A component is not required to be of corrosion resistant material when failure of the component does not affect the ability of the device to meet the requirements of this standard.

Exception No. 3: An expendable component used as a sacrificial anode meets the intent of the requirement where galvanic compatibility is not provided.

31.2.2 A nonmetallic component of an inflation system shall resist the deteriorating effects of exposure to light, water, gasoline, detergent, dry cleaning solvent, and motor oil (See the Exposure portion of Table 32.1 – Table 32.5).

31.3 Oral inflation systems

31.3.1 An oral inflation system shall be provided with a pressure-actuated inlet valve (See the compliance criteria under Oral Systems in Table 32.5). The pressure-actuated inlet valve shall not require a pull, push, or other mechanical action to open the inflation valve.

31.3.2 A mouthpiece for an oral inflation system shall not contain:

a) Lead compounds of which the lead content exceeds 0.5 percent of the total weight of the contained solids (including pigments, film solids, and driers);

b) Compounds of antimony, arsenic, mercury, or selenium of which the metal content individually or in total exceeds 0.06 percent by weight of the contained solids (including pigments, film solids, and driers); or

c) Barium compounds of which the water soluble barium exceeds 1 percent of the total barium.

31.3.3 An oral inflation mechanism shall not be able to be locked in the open or closed position. A friction fit dust cap shall not be used to lock the mechanism open.

31.4 Actuation and rearming of manual, manual-auto, and automatic inflation systems

31.4.1 Rearming an inflation system shall not require the use of tools, unless the tool is a non-detachable part of the inflation system or is provided with every inflation system rearm kit.

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

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

31.4.4 For systems which do not have cylinder seal indication, the manual portion of an manual-auto or manual inflation system shall:

a) Be designed such that the manual system is not able to be reset without first unseating the spent cylinder; or

b) Incorporate user-installed indicating tabs, clips, or pins for use when rearming the device that allow the user to indicate that a charged cylinder has been installed. Such tabs, clips, or pins shall completely disengage or otherwise be ejected from the device during manual activation.

31.4.5 A manual, manual-auto, or automatic inflation system shall not permit installation of a loaded cylinder unless the device is properly reset (i.e., a cylinder discharges during installation when a system has not been reset).

Exception No. 1: Use Code 6F systems which are convertible manual-auto inflation systems are not required to comply when designed such that the manual portion of the system is rearmed while the automatic portion of the system is disarmed and the inflation system indicator(s) comply with 31.1.4.

Exception No. 2: Not applicable for one-time use inflation systems.

31.4.6 The pull mechanism portion of a manual or manual-auto inflation system shall be provided in a highly visible color intended to contrast with the color of the PFD.

31.5 Means for verification of mechanism operation

31.5.1 A manual, manual-auto, or automatic inflation system shall be designed such that the user is capable of testing the system during rearming to visually verify that all mechanisms are operating using only components which are integral to the device and without discharging a cylinder. For electronic inflation systems, the system shall be tested separately with a fully charged and depleted battery.

31.5.2 When an electrical switch is used to verify the mechanism operation, the switch shall comply with the Standard for Switches for Appliances – Part: General Requirements UL 61058-1 and the Standard for Switches for Appliances – Part 1-2: Requirements for Electronic Switches UL 61058-1-2 and shall have the following minimum classifications:

a) Intended for use at ambient temperatures of 0°C ≤ T ≤ 70°C.

b) 100,000 cycles.

c) If not externally protected from water ingress, a IPX8 degree of protection.

31.5.3 The electrical switch shall be protected or recessed to prevent incidental impact, however shall be such that the user can easily access without the means of a tool.

31.6 Inflation medium and cylinders

31.6.1 A cylinder for an automatic, manual-auto, or manual system shall meet the following requirements.

a) The cylinder shall be of seamless construction and shall not be rechargeable following release of the gas charge.

b) Non-indicating cylinders shall comply with the requirements specified in Table 32.2 when subjected to the tests therein.

c) Cylinder seal indicating cylinders shall comply with the requirements specified in Table 32.3 when subjected to the tests therein.

31.6.2 An inflation medium shall not be flammable or more toxic than carbon dioxide, nor shall it generate compounds formed from reaction with water, compartment wall, or other materials that are flammable or more toxic than carbon dioxide.

31.7 Indicators

31.7.1 Automatic, manual-auto, and manual inflation systems, and cylinder seal indicating cylinders shall be provided with status indicators which provide information to the user as to whether the device is correctly armed as follows:

a) Use Code 1F – The inflation system with cylinder shall incorporate status indication including cylinder seal indication in a single point indicator. The indicator shall be integral to the device or cylinder and reset to a positive or "ready" condition upon rearming of the system.

b) Use Codes 2F – The inflation system with cylinder shall incorporate status indication including cylinder seal indication using single or multiple point indicator(s). All indicators shall actuate simultaneously and shall indicate ready when completely rearmed.

c) Use Codes 3F – The inflation system with cylinder shall incorporate status indication including cylinder seal indication. The readiness of the system shall be displayed using single or multiple point indicator(s).

d) Use Codes 6F – The inflation system with cylinder shall, when considered with the use conditions for its acceptance on a PFD, incorporate status indication except for the status of the cylinder (e.g., the user is required to check the cylinder status by removing it, inspecting it, and replacing it). The readiness of the system shall be displayed using single or multiple point indicator(s).

e) All status indicators shall be designed such that a user is able to visually verify that all "ready" indicators are present upon inspection during rearming without using tools not integral to, or provided with, the system and without discharging a cylinder.

f) For all status indicators, the color green shall be used to indicate an armed or "ready" condition and the color red shall be used to indicate an unarmed or "not ready" condition. A red status indicator shall be evident whenever a green status indicator is absent. In the case of pull pins or tabs for Use Code 3F and 6F status indicators, this may be accomplished by having the red indicator located beneath the green indicator so as to be visible after, but not readily apparent before, the pin or tab is removed.

g) All status indicators shall be grouped or located such that when installed on a device in their intended position, they are viewed simultaneously when examined prior to donning. Cylinder seal indicators shall be readily visible over the range described in Table 31.1 when the cylinder is attached to the inflator.

h) Electronic indicators shall be provided with a means to test the working condition of the circuitry and the adequacy of the power supply.

i) The green indicators on single use, replaceable inflation systems or cylinder seal indicating cylinders shall not be reusable.

Table 31.1
Indicator visibility

	Red indicator	Green indicator
Minimum Viewing Distance	2 meters (6.5 feet)	2 meters (6.5 feet)
Horizontal (side-to-side) Viewing Range	90 degree including head-on	90 degree including head-on
Vertical (top-to-bottom) Viewing Range	90 degree including head-on	90 degree including head-on

31.8 Window material

31.8.1 Flexible film window material, suitable for either welding or sewing or both, used as a non-load bearing component for viewing a CO^2 cylinder and/or the inflation indicator(s) of an inflation system, shall comply with the requirements of 31.8.2 and 31.8.3 and Table 31.1 and Table 31.2.

Table 31.2
Window material

Test	Exposure	Test method	Number of samples	Compliance criteria
Tensile breaking strength and elongation	1. Standard Conditioning. 2. Xe_{500}	ASTM D412, Method A, Die A.	20 (5 samples in each direction for each exposure)	Following exposure 1, the minimum average strength shall be 62 N (14 pounds force) and the minimum elongation shall be 10% for each sample. Following exposure 2 the minimum strength shall be 53 N (12 pounds force).
Cold crack/flexibility	minus 18 ±1°C (0 ±2°F) for 1 h	See 26.3.1 and 26.3.2	10	No more than two (2) samples shall break.
Visual clarity	1. Xe_{500} 2. Abrasion Conditioning	ASTM D4157. See 31.8.2.	4 (1 sample in each direction for each exposure)	Following each exposure, the colors red and green shall be correctly distinguishable for each sample.

31.8.2 Window material samples shall be abrasion conditioned with 250 double rubs (continuous cycle) of a No. “0” sand paper under a tension of 9 N (2 pounds) and under a load of 9 N (2 pounds) in accordance with ASTM D4157. The tension of the samples shall be maintained throughout conditioning.

31.8.3 The visual clarity tests, in accordance with 31.8.3 – 31.8.6, shall be used to determine if inflation system indicators are correctly distinguishable over the viewing range described in Table 31.1 when viewed through the window material after Xenon weathering and abrasion conditioning.

31.8.4 For the visual clarity tests in Table 31.2, a minimum of two samples for each direction lengthwise and widthwise, shall be cut to 230 by 48 mm (9 by 1-7/8 inch).

31.8.5 The compliance with the visual clarity of the window material shall be determined by a qualified observer capable of correctly distinguishing the red/green indicators prior to the mounting of the window material.

31.8.6 The viewing apparatus for the visual clarity test shall consist of two representative inflation mechanisms, one indicating red and the other indicating green, mounted in a flat panel. The inflation mechanism shall be mounted so that its outside is flush with the outside of the panel. The window material samples shall be mounted directly over the inflation mechanism with the conditioned surface area directly over the indicator. The viewing apparatus shall be placed at a distance of 2 meters (6.5 feet) from the observer’s eyes and the inflation mechanism indicator at a height equal to the observer’s eyes when seated. The apparatus shall be capable of movement through the full viewing range as specified in Table 31.1. The light source shall be a 40 watt incandescent daylight bulb placed at a height of 1 meter (3.25 feet) directly over the observer’s head. The test shall be performed in a dark non-reflective environment (no visible light when the 40 watt incandescent daylight bulb is not lit).

32 Performance

32.1 General

32.1.1 Inflation systems shall comply with the requirements specified in Table 32.1 – Table 32.5 when subjected to the tests therein. For manual-auto inflation systems, the automatic portion of the system shall comply with the requirements for automatic inflation systems and the manual portion of the system shall comply with the requirements for manual inflation systems.

Exception: Inflation systems intended for use only in personal flotation devices marked "Do not dry clean," or the equivalent, are not required to comply with the requirements for exposure to perchloroethylene.

32.1.2 Over-pressure relief valve systems shall comply with the requirements specified in Table 32.6 when subjected to the tests therein.

32.1.3 When a system, including cylinder seal indicating cylinders, has a form of construction, or employs metals in a combination that is not known to provide required resistance to corrosion, resistance to dezincification, or galvanic compatibility, samples are to be tested in accordance with Table 32.1 after being subjected to 720 h of salt spray exposure in accordance with the Standard Test Method for Salt Spray (Fog) Testing, ASTM B117-94, in addition to tests following Standard Exposure (See Table 2.2).

Exception No. 1: An expendable component (for example, a gas cylinder) is not required to be of corrosion-resistant material, when the component is provided with a durable zinc or cadmium plating, or is equivalently protected against corrosion.

Exception No. 2: A component is not required to be of corrosion resistant material when failure of the component does not affect the ability of the device to meet the requirements of this standard.

Exception No. 3: An expendable component used as a sacrificial anode meets the intent of the requirement where galvanic compatibility is not provided.

32.2 Use characteristics test – automatic, manual-auto, and manual inflation systems

32.2.1 Each Use Code 1F, 2F, 3F, and 6F automatic, manual-auto, or manual inflation systems, and each cylinder seal indicating cylinder shall meet the compliance criteria in Table 32.1, Table 32.2, or Table 32.3 as appropriate, when tested in accordance with 32.2.2 – 32.2.9.

32.2.2 Human test participants as specified in Table 32.7 are to be employed. A test participant shall not be familiar with the particular device under test, but is to be familiar with PFDs in general.

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

a) "Have you gone boating?"; and

b) "What does a life vest (or life jacket) do for you?"

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

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

a) The general purpose of an inflatable PFD.

b) General information regarding cylinders.

c) The general principal and method of manual inflation.

d) The general principal and method of automatic inflation.

32.2.5 For status indicator test sample preparations samples of the candidate inflation systems are to be mounted on boards or on inflation cells as follows:

a) One sample properly armed.

b) One sample normally fired manually for devices with manual systems.

c) One sample normally fired automatically for devices with automatic systems.

d) Samples incorrectly rearmed, excluding replacement with a fired cylinder.

e) For Use Code 1F systems, samples incorrectly rearmed, including installation of a fired cylinder.

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

Table 32.1
Automatic inflation systems

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Use Characteristics	SC	32.2	As required by design features		Automatic inflation systems, correct identification regarding system status, including/excluding cylinder seal condition, shall be accomplished by at least the following percent for the 25 or more subjects performing the status indicator evaluation:
				1F	96 percent (including cylinder seal condition)
				2F and 3F	92 percent (including cylinder seal condition)
				5H and 6F	92 percent (excluding cylinder seal condition) Automatic inflation systems, proper rearming of the inflation system shall be accomplished by at least the following percent for the 15 or more subjects performing the rearming evaluation:
				1F	93 percent
				2F, 3F, 5H and 6F	86 percent
Automatic Operability	**1.** SC	32.3.1 –32.5.3	6 plus 2 extra water sensing elements (when expendable) for each sample. Note: Non-indicating cylinders are conditioned as specified in 32.3.1. Cylinder seal indicating cylinders are conditioned as specified in Table 32.3.	1F, 2F, 3F, 5H, and 6F	**1. Exposures 1 – 6, 7c, 7d, and 8**, the actuation time shall be not more than 5 s following immersion for each of the trials (for example, half in fresh water, half in salt water). Except for minimal residual vapor, the gas in the cylinders shall be completely discharged after each trial. **2.** Starting within 10 s of removal from the cold chamber following Exposure 8a, samples shall be dropped 3 times onto a concrete surface from a height of 6 feet (1.8 m). The samples shall then be subjected to Exposure 8b. Following Exposure 8b, the actuation time shall be not more than 5 s following immersion. **3. Exposure 8**, samples shall have no visible pitting or other damage on any surface.
	2. Xe_{750} or Nt_{75}		4		
	3. 70 h immersion in Ref. Fuel B as		4		

Table 32.1 Continued on Next Page

Table 32.1 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
	specified in ASTM D471-98				
	3a. 3 separate 5 min immersions in Ref. Fuel as specified in ASTM D471-98 with 30 min drying periods between immersions.[e]		4		
	4. 70 h immersion in IRM 902 (Calumet Oil No. 2)		4		
	5. 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water		4		
	6. 70 ±2°C (158 ±4°F) for 168 h[d]		100 (may be 10 trials on 10 complete samples)[l]		
	7a. -30 ±2°C (-22 ±4°F) for 24 h		4		
	7b. 0 ±2°C (32 ±4°F) for 24 h[d]		4		
	7c. High to Low Temperature[f]		4		
	7d. Low to High Temperature[g]		4		
	8. 720 h of Salt Spray as specified in ASTM B117-94		4		
Discharge	Same as Automatic Operability Exposures 1, 2, 3, 4, 5, 6, 7, 7b, and 8	32.7.1 – 32.7.12	Three of the samples from exposures 1, 2, 5, and 8 from the Automatic Operability Test with new water sensing elements. Three new samples complete with water sensing elements are to be used for exposures 3, 4, 6 and 7b.[j]	1F, 2F, 3F, 5H, and 6F	**Exposures 1 – 6, and 8**, the time for actuation following immersion shall be not more than 5 s.
				1F, 2F and 6F	In addition, systems shall achieve 150 N (33.7 lbf) within 10 s following immersion.
				3F and 5H	In addition, systems shall achieve 100 N (22.5 lbf) within 10 s following immersion.
				1F, 2F, 3F, 5H, and 6F	Exposure 7b, the time for actuation following immersion shall be not more than 5 s.
				1F, 2F, and 6F	In addition, systems shall achieve 75 N (16.8 lbf) within 10 s following immersion.
				3F and 5H	In addition, systems shall achieve 50 N (11.2 lbf) within 10 s following immersion.

Table 32.1 Continued on Next Page

Table 32.1 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Parallel Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, 5H, and 6F	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 75 lbf (334 N) is applied parallel to the surface of the chamber material at the point of attachment, for at least 5 min.
Perpendicular Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, 5H, and 6F	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 250 lbf (1112 N) is applied outwardly from and perpendicular to the surface of the chamber material at the point of attachment, for at least 3 s.
Hydrostatic Proof Pressure	SC	TSO - C13e 5.6.3	1	1F, 2F, 3F, 5H, and 6F	The inflation system shall withstand an internal hydrostatic pressure of 1500 psig (10342 kPa gauge) without deformation or leakage.
Proof Pressure	SC	TSO - C13e 5.6.3	The sample from the Hydrostatic Proof Pressure Test.[j]	1F, 2F, 3F, 5H, and 6F	After the Hydrostatic Proof Pressure Test, the inflation system shall not leak when subjected to an air pressure of 2 psig (14 kPa gauge) for 30 s, followed by an air pressure of 40 psig (276 kPa gauge) for 30 s.
Air Flow	SC	TSO - C13e 5.6.4	1	1F, 2F, 3F, 5H, and 6F	The inflation system meets the intent of the requirement when minimum air flow of 4 lpm (1 gpm) at an inlet pressure of 40 psig (276 kPa gauge).
Vacuum	SC	TSO - C13e 5.6.4	The sample from the Air Flow Test.[j]	1F, 2F, 3F, 5H, and 6F	The inflation system shall not show a loss of pressure greater than 0.05 inches (1.3 mm) of water in 1 min or 0.1 inches (2.5 mm) of water in 1 h when subjected to a vacuum of 12 inches (0.3 m) of water applied so as to reduce the seating spring pressure and with atmospheric pressure on the other side.
System Durability[k]	SC	32.10.1	1 complete	1F, 2F, 3F, 5H, and 6F	The inflation system shall operate as intended.
Pull	SC	32.12	1	1F, 2F, 3F, 5H, and 6F	The inflation system shall not be damaged.
Humid Atmosphere / Piercing	**1.** SC **2.** Exposure 1 followed by 168 h at 49 ±2°C (120 ±4°F) and 95 ±3 % relative humidity. **3.** Exposure 1 followed by 168 h at 49 ±2°C (120 ±4°F) and 85 ±5 % relative humidity.	32.9.1 – 32.9.3	100 complete (may be 2 trials on 50 complete samples)[l]	1F, 2F, 3F, 5H, and 6F 1F 2F and 6F	95 percent of the samples shall not actuate during the exposure. Those samples that did not actuate during the exposure shall completely pierce the standard proof disc within 5 s when immersed following the exposure.
Inadvertent Puncture[h]	SC	32.14	1	1F, 2F, 3F, 5H, and 6F	The cylinder shall not be punctured.
Impact Resistance[m]	SC	UL 12402-9, 5.5.3	1	1F, 2F, 3F, 5H, and 6F	The automatic inflation system and electronic indicators shall operate as intended.

Table 32.1 Continued on Next Page

Table 32.1 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Solid-State Circuitry Test[l]	Not Applicable	32A	m	1F, 2F, 3F, 5H, and 6F	The opening or short-circuiting of any single solid-state component shall not result in any inappropriate action of electronic inflation system.
Battery Discharge[l]	Not Applicable	32B	2	1F, 2F, 3F, 5H, and 6F	The automatic inflation system shall operate as intended. The electronic indicators shall operate as intended before and after automatic inflation.

[a] See Table 2.2 for conditioning details.

[b] Color dependent. See 2.4.

[c] For polymeric/metallic inflation systems, a minimum of 185 samples with water sensing elements plus 300 extra water sensing elements, plus 300 cylinders, 110 proof discs and holders, 4 manifolds welded to 5 inch by 5 inch (100 mm by 100 mm) inflation chamber material.

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

[e] After the last submergence period, the sample is to be removed from the liquid and the excess liquid allowed to run off for 5 min.

[f] Each sample is to be placed in a circulating-air oven maintained at 70 ±2°C (158 ±4°F) for 24 h. The samples are then to be placed in a cold chamber at minus 30 ±2°C (minus 22 ±4°F) for 24 h. The temperature of the cold chamber is then to be raised to 0 ±2°C (32 ±4°F) for 24 h.

[g] Each sample is to be placed in a cold chamber at minus 30 ±2°C (minus 22 ±4°F) for 24 h. The samples are then to be placed in a circulating-air oven maintained at 70 ±2°C (158 ±4°F) for 24 h.

[h] Only conducted when a CO_2 cylinder is in constant contact with the pierce pin.

[i] Four samples, per exposure, for one-time use inflation systems.

[j] New samples shall be used for one-time use inflation systems.

[k] Not required for one-time use inflation systems.

[l] For electronic inflation systems only.

[m] The number of samples may vary based on the solid-state devices incorporated into the circuitry.

Table 32.2
Non-indicating cylinders

Tests	Exposure[a]	Test method	Number of samples[b]	Use Codes	Compliance criteria
Hydrostatic Proof Pressure	SC		1 for each separate exposure	5H and 6F	The cylinder, excluding the sealing cap, shall withstand an internal hydrostatic pressure of 54 MPa gauge (7830 psig) applied through the cap area at a rate of approximately 2 MPa gauge (290 psig) per s without bursting.
High Temperature	65 ±2°C (149 ±4°F) for 30 min			5H and 6F	No loss of gas or deformation of the cylinder shall occur[d].
Fill Ratio	SC			5H and 6F	The nominal mass in grams of carbon dioxide shall not exceed 75 percent of the volume (water capacity) in ml of the cylinder.[e]

Table 32.2 Continued on Next Page

Table 32.2 Continued

Tests	Exposure[a]	Test method	Number of samples[b]	Use Codes	Compliance criteria
Salt Spray	96 h	ASTM B117-97		5H and 6F	The outer surface of the inflation medium cylinder shall exhibit no corrosion of the base construction metal and the outer surface of steel cylinders shall exhibit no red rust.
Gross Weight	SC			5H and 6F	The gross weight of the cylinder shall be the marked minimum gross weight (minus 0 +10 percent of the marked nominal mass of gas or +2 grams, whichever is the greater).
Piercing	SC	32.13	100	5H and 6F	The average Piercing Force + 3 standard deviations for the 100 samples tested shall be less than 58.3 lbf (260 N). The average Piercing Work + 3 standard deviations for the 100 samples tested shall be less than 3.1 in-lbf (0.35 N·m).

[a] See Table 2.2 for conditioning details.

[b] A minimum of 25 samples.

[c] A slight deformation of the sealing cap is permitted. After conditioning, the piercing surface of the sealing cap is to be within 0.012 inch (0.3 mm) of the plane of the outer diameter of the sealing cup.

[d] When a cylinder complies with SAE AS 6011 construction specifications for Type I, II, or III cylinders then the 75 percent volume requirement does not apply.

Table 32.3
Cylinder seal indicating cylinders

Tests	Exposure[a]	Test method	Number of samples[b]	Use Codes	Compliance criteria
Hydrostatic Proof Pressure #1	SC		1	1F, 2F and 3F	The cylinder, excluding the indicating mechanism and sealing cap, shall withstand an internal hydrostatic pressure of 54 MPa gauge (7830 psig) applied through the cap area at a rate of approximately 2 MPa gauge (290 psig) per s without bursting.
Hydrostatic Proof Pressure #2	SC	TSO-C13[d], 5.6.3[c]	1	1F, 2F and 3F	The indicating mechanism and its attachment to the inflation system shall withstand an internal hydrostatic pressure of 10.3 MPa gauge (1500 psig) without deformation or leakage.
High Temperature	65 ±2°C (149 ±4°F) for 30 min		1	1F, 2F and 3F	No loss of gas or deformation of the cylinder or indicating mechanism shall occur[e].
Fill Ratio	SC		1	1F, 2F and 3F	The nominal mass in grams of carbon dioxide shall not exceed

Table 32.3 Continued on Next Page

Table 32.3 Continued

Tests	Exposure[a]	Test method	Number of samples[b]	Use Codes	Compliance criteria
					75 percent of the volume (water capacity) in ml of the cylinder.[f]
Gross Weight	SC		1	1F, 2F and 3F	The gross weight of the cylinder with indicating mechanism shall be the marked minimum gross weight (minus 0 +10 percent of the marked nominal mass of gas or +2 grams, whichever is the greater).
Use Characteristics	SC	Section 32.2[c,f]	As required by design features	1F, 3F and 5H 2F 1F 2F, 3F, and 5H	Correct identification regarding status shall be accomplished by at least 96 percent of the 25 or more subjects performing the status indicator evaluation. Correct identification regarding status shall be accomplished by at least 92 percent of the 25 or more subjects performing the status indicator evaluation. Proper rearming shall be accomplished by at least 93 percent of the 15 or more subjects performing the rearming evaluation. Proper rearming shall be accomplished by at least 86 percent of the 15 or more subjects performing the rearming evaluation.
Operability / Discharge / Conditionings	**1.** SC **2.** Xe_{750} or Nt_{75} **3.** 70 h immersion in ASTM Ref. Fuel B **3a.** 3 separate 5 min. immersions in ASTM Ref. Fuel B with 30 min. drying periods between immersions.[g] **4.** 70 h immersions in IRM 902 (Calumet Oil No. 2) **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water **6.** 60 ±2°C (140 ±4°F) for 720 h **7.** -30 ±2°C (-22 ±4°F) for 24 h **7a.** -30 ±2°C (-22 ±4°F) for 24 h	32.4.1	21 for automatic systems, 12 for manual systems 7 for automatic systems, 12 for manual systems 7 for automatic systems, 12 for manual systems 4 for automatic systems operability 7 for automatic systems, 12 for manual systems 7 for automatic systems, 12 for manual systems 103 for automatic systems 12 for manual systems 9 for manual systems operability test 7 for automatic systems, 3 for manual systems discharge test 4 for automatic systems operability	1F, 2F, and 3F	**1.** The cylinder and indicating mechanism shall operate as specified in the Acceptance criteria for the operability and discharge tests in Table 32.1 for automatic inflation systems, or Table 32.2 for manual inflation systems. **2.** Within 10 s of removal from the cold chamber following Exposures 7 and 7a, samples shall be dropped 3 times onto a concrete surface from a height of 6 feet (1.8 m). The 7a samples shall then be subjected to Exposure 7b. Following Exposure 8 the cylinders and indicating mechanisms shall operate as intended as specified in the Compliance criteria for the operability tests in Table 32.2 for manual inflation systems. Following Exposure 7b the cylinders and indicating mechanisms shall operate as intended as specified in the Compliance criteria for the operability and discharge tests

Table 32.3 Continued on Next Page

Table 32.3 Continued

Tests	Exposure[a]	Test method	Number of samples[b]	Use Codes	Compliance criteria
	7b. 0 ±2°C (32 ±4°F) for 24 h **7c.** High to Low Temperature[h] **7d.** Low to High Temperature[h] **8.** 96 h of Salt Spray as specified in ASTM B117-97		4 for automatic operability 7 for automatic systems, 12 for manual systems		in Table 32.1 for automatic inflation systems, or for the discharge tests in Table 32.2 for manual inflation systems.
Humid Atmosphere	**1.** SC **2.** Exposure 1 followed by 168 h at 49 ±2°C (120 ±4°F) and 95 ±3 % relative humidity **3.** Exposure 1 followed by 168 h at 49 ±2°C (120 ±4°F) and 85 ±5 % relative	32.4.1	100 for automatic systems	1F, 2F, 3F, 5H, and 6F 1F 2F, 3F, 5H, and 6F	95 percent of the samples shall not actuate during the exposure. Those samples that did not actuate during the exposure shall completely pierce the standard proof disc within 5 s when immersed following the exposure.
Pull	SC	32.12	1	1F, 2F, and 3F	The cylinder, it's indicating mechanism, or seal shall not be damaged.
Piercing	SC	32.13	100	1F, 2F, and 3F	The average Piercing Force + 3 standard deviations for the 100 samples tested shall be less than 58.3 lbf (260 N). The average Piercing Work + 3 standard deviations for the 100 samples tested shall be less than 3.1 in-lbf (0.35 N·m).

[a] See Table 2.2 for conditioning details.

[b] A minimum of 320 samples when intended for automatic systems. A minimum of 170 for manual systems.

[c] This test shall be conducted with the cylinder attached to an inflation system.

[d] A slight deformation of the sealing cap is permitted. After conditioning, the piercing surface of the sealing cap is to be within 0.012 inch (0.3 mm) of the plane of the outer diameter of the sealing cap.

[e] When a cylinder complies with SAE AS 6011 construction specifications for Type I, II, or III cylinders then the 75 percent volume requirement does not apply.

[f] This test is to be conducted in concert with the Automatic Inflation System Use Characteristics Test described in Table 32.1.

[g] After the last submergence period, the sample is to be removed from the liquid and the excess liquid allowed to run off for 5 min.

[h] Each sample is to be placed in a circulating-air oven maintained at 60 ±2°C (140 ±4°F) for 24 h. The samples are then to be placed in a cold chamber at minus 30 ±2°C (minus 22 ±4°F) for 24 h. The temperature of the cold chamber is then to be raised to 0 ±2°C (32 ±4°F) for 24 h.

[i] Each sample is to be placed in a cold chamber at minus 30 ±2°C (minus 22 ±4°F) for 24 h. The samples are then to be placed in a circulating-air oven maintained at 60 ±2°C (140 ±4°F) for 24 h.

Table 32.4
Manual inflation systems

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Use Characteristics	SC	32.2	As required by design features		Manual inflation systems, correct identification regarding system status shall be accomplished by at least the following percent of the 25 or more subjects performing the status indicator evaluation:
				1F	96 percent (including cylinder seal condition)
				2F	92 percent (including cylinder seal condition)
				3F, 5H and 6F	92 percent (including cylinder seal indication when provided)
					Manual inflation systems, proper rearming of the inflation system shall be accomplished by at least the following percent of the 25 or more subjects performing the rearming evaluation:
				1F	93 percent
				2F, 3F, 5H and 6F	86 percent
Manual Operability	**1.** SC **2.** Xe_{750} or Nt_{75} **3.** 70 h immersion in Ref. Fuel B as specified in ASTM D471-98 **4.** 70 h immersion in IRM 902 (Calumet Oil No. 2) **5.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent by volume in no greater than "1" hardness water **6.** 70 ±2°C (158 ±4°F) for 168 h[d] **7.** -30 ±2°C (-22 ±4°F) for 24 h[d] **8.** 720 h of Salt Spray as specified in ASTM B117-94	32.5.1 – 32.5.5	3 for each separate conditioning. (Total 27 samples) Note: Non-indicating cylinders are conditioned as specified in 32.5.1 Cylinder seal indicating cylinders are conditioned as specified in Table 32.3.	1F, 2F, 3F, and 5H	**1.** Following Exposures 1 - 6, and 8, the force required to puncture the CO_2 cylinder shall be not less than 3 lbf (13 N) and not more than 15 lbf (67 N) for each of the trials, and the average force shall be not less than 5 lbf (22 N). Except for minimal residual vapor, the CO_2 in the cylinders shall be completely discharged after each trial. **2.** Starting within 10 s of removal from the cold chamber following Exposure 7, samples shall remain operable when dropped three times onto a concrete surface from a height of 6 feet (1.8 m). The force required to puncture the CO_2 cylinder shall be not less than 3 lbf (13 N) and not more than 15 lbf (67 N) for each of the trials, and the average force shall be not less than 5 lbf (22 N). **3.** Following Exposure 8, samples shall have no visible pitting or other damage on any surface.
Discharge	Same as Operability for Exposures 1 – 6 and 8	32.7.1 – 32.7.12	The samples from each conditioning from the Operability Test.	1F, 2F, 3F, and 5H	**For Exposures 1 – 6, and 8**, the time for discharge following actuation shall be not more than 5 s.
				1F and 2F	Systems shall achieve 33.7 lbf (150 N) within 5 s of actuation.

Table 32.4 Continued on Next Page

Table 32.4 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
	For Exposure 7, 0 ±2°C (32 ±4°F) for 24 h.			3F, 5H and 6F 1F and 2F 3F, 5H and 6F	Systems shall achieve 22.5 lbf (100 N) within 5 s of actuation. **For Exposure 7**, the time for discharge following actuation shall be not more than 5 s. Systems shall achieve 16.8 lbf (75 N) within 5 s of actuation Systems shall achieve 11.2 lbf (50 N) within 5 s of actuation
Parallel Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, and 5H	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 75 lbf (334 N) is applied parallel to the surface of the chamber material at the point of attachment, for at least 5 min.
Perpendicular Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, and 5H	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 250 lbf (1112 N) is applied outwardly from and perpendicular to the surface of the chamber material at the point of attachment, for at least 3 s.
Pull Cord Strength	**1.** SC **2.** Xe_{750} or Nt_{75}	TSO - C13e 5.6.2	1 for each separate conditioning. Note - use of Operability Test samples is an alternative	1F, 2F, 3F, and 5H	The pull cord, its attachment to the tab, and its attachment to the inflator shall withstand a force of 100 lbf (445 N) for 3 s without failing or separating from the inflator.
Hydrostatic Proof Pressure	SC	TSO - C13e 5.6.3	1	1F, 2F, 3F, and 5H	The inflation system shall withstand an internal hydrostatic pressure of 1500 psig (10342 kPa) without deformation or leakage.
Proof Pressure	SC	TSO - C13e 5.6.3	The sample from the Hydrostatic Proof Pressure Test.	1F, 2F, 3F, and 5H	After the Hydrostatic Proof Pressure Test, the inflation system shall not leak when subjected to an air pressure of 2 psig (14 kPa gauge) for 30 s, followed by an air pressure of 40 psig (276 kPa gauge) for 30 s.
Air Flow	SC	TSO - C13e 5.6.4	1	1F, 2F, 3F, and 5H	The inflation system shall allow a minimum air flow of 4 lpm (1 gpm) at an inlet pressure of 40 psig (276 kPa gauge).
Vacuum	SC	TSO - C13e 5.6.4	The sample from the Air Flow Test.	1F, 2F, 3F, and 5H	The inflation system shall not show a loss of pressure greater than 0.05 inches (1.3 mm) of water in 1 min or 0.1 inches (2.5 mm) of water in 1 h when subjected to a vacuum of 12 inches (0.3 m) of water applied so as to reduce the seating spring pressure and with

Table 32.4 Continued on Next Page

Table 32.4 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
					atmospheric pressure on the other side.
System Durability	SC	32.10.1	1 complete sample	1F, 2F, 3F, and 5H	The inflation system shall operate as intended.
Pull	SC	32.12	1	1F, 2F, 3F, and 5H	The inflation system shall not be damaged.
Inadvertent Puncture[e]	SC	32.14	1	1F, 2F, 3F, 5H, and 6F	The cylinder shall not be punctured.

[a] See Table 2.2 for conditioning details.

[b] Color dependent. See 2.4.

[c] For polymeric/metallic inflation systems, a minimum of 40 samples, and 200 cylinders, and 4 manifolds welded to 5 inch by 5 inch (100 mm by 100 mm) inflation chamber material.

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

[e] Only conducted when a CO_2 cylinder is in constant contact with the pierce pin.

Table 32.5
Oral inflation systems

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Oral Operability	**1.** SC **2.** Xe_{750} or Nt_{75} **3.** 70 h immersion in Ref. Fuel B as specified in ASTM D471. **4.** 3 separate 5 min immersions in Ref. Fuel B as specified in ASTM D471 – with 30 min drying periods between immersions.[d] **5.** 70 h immersion in IRM 902 (Calumet Oil No. 2) **6.** 70 h immersion in 0.5 percent per volume AATCC-2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water **7.** 70 ±2°C (158 ±4°F) for 168 h **8.** -30 ±2°C (-22 ±4°F) for 24 h **9.** 720 h of Salt Spray as specified in ASTM B117	32.6.1 – 32.6.3	3 for each separate conditioning (Total 27 samples)	1F, 2F, 3F, and 5H	The crack pressure shall not exceed 0.44 psig (3 kPa gauge).
Parallel Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, and 5H	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 75 lbf (334 N) is applied parallel to the surface of

Table 32.5 Continued on Next Page

Table 32.5 Continued

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
					the chamber material at the point of attachment, for at least 5 min.
Perpendicular Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F, 2F, 3F, and 5H	The inflator and the joint between the inflator and the inflation chamber material shall not fail when a force of 100 lbf (445 N) is applied outwardly from the perpendicular to the surface of the chamber material at the point of attachment, for at least 3 s.
Back Pressure	Same as Oral Operability	TSO-C13e 4.1.4.2	The samples from the Operability Test.	1F, 2F, 3F, and 5H	The samples shall not leak when subjected to a back pressure of 0 to 10 psig (0 to 69 kPa gauge). When leakage occurs using samples from the Salt Spray exposure or Detergent exposure, the valve is rinsed from the outside by agitating the sample in fresh water for a period of not more than 15 s to dissolve any imbedded particles, and the test repeated.

[a] See Table 2.2 for conditioning details.

[b] Color dependent. See 2.4.

[c] For polymeric/metallic inflation systems, a minimum of 30 samples.

[d] After the last submergence period, the sample is to be removed from the liquid and the excess liquid allowed to run off for 5 min.

Table 32.6
Over-pressure relief valve systems

Tests	Exposure[a]	Test method	Number of samples[b,c]	Use Codes	Compliance criteria
Operability	**1.** SC **2.** Xe_{750} or Nt_{75} **3.** 70 h immersion in Ref. Fuel B as specified in ASTM D471 **4.** Three separate 5-min immersions in Ref. Fuel B as specified in ASTM D471 with 30 min drying periods between immersions.[d] **5.** 70 h immersion in IRM 902 (Calumet Oil No. 2) **6.** 70 h immersion in 0.5 percent per volume AATCC 2003 Standard Reference Liquid Detergent, by volume, in no greater than "1" hardness water **7.** 70 ±2°C (158 ±4°F) for 168 h **8.** -30 ±2°C (-22 ±4°F) for 24 h **9.** 720 h of Salt Spray as specified in ASTM B117	32.11.1	3 for each separate conditioning. (Total 27 samples)	1F	The crack pressure shall not exceed 120 percent of the rated pressure and shall not be less than 80 percent of the rated pressure. The closing pressure shall be not less than 80 percent of the measured crack pressure.
Parallel Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F	The inflator and the joint between the over-pressure relief valve and the inflation chamber material shall not fail when a force of 75 lbf (334 N) is applied parallel to the surface of the chamber material at the point of attachment, for at least 5 min.
Perpendicular Strength of Attachment	SC	32.8.1 – 32.8.3	1	1F	The inflator and the joint between the over-pressure relief valve and the inflation chamber material shall not fail when a force of 100 lbf (445 N) is applied outwardly from and perpendicular to the surface of the chamber material at the point of attachment, for at least 3 s.

[a] See Table 2.2 for conditioning details.

[b] Color dependent. See 2.4.

[c] For polymeric/metallic inflation systems, a minimum of 30 samples.

[d] After the last submergence period, the sample is to be removed from the liquid and the excess liquid allowed to run off for 5 min.

Table 32.7
Test participant selection

Type of inflation system	Number of test participants (group size)
Manual Inflation System	1 group of 25
Automatic Inflation System	1 group of 25
Manual-Auto Inflation System	1 group of 25
Note: A minimum of 5 and a maximum of 15 test participants shall be obtained for each subject group from each of the following age groups: a) 16 – 25 years; b) 26 – 50 years; and c) 51 and older.	

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

32.2.7 At least 24 of the 25 participants shall identify the correct sample for a Use Code 1F system. At least 23 of the 25 test participants shall identify the correct sample for Use Code 2F, 3F, or 6F systems. If the required number of participants do not identify the correct sample, and at least 16 of the 25 test participants identify the correct sample, each test participant who identifies an incorrect sample is to be instructed as to why the sample they identified is visibly incorrect. These test participants shall again review the orientation video and manufacturer's instructions and shall then be asked the following questions:

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

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

c) For manually actuated systems, "What is this for?" (while pointing out the manual lanyard)

d) "What is this for?" (while pointing out the cylinder)

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

32.2.8 For test participant qualification for serviceability test and following completion of the Status Indicator Evaluation, each test participant is to be given the following written questions to respond to:

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

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

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

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

Test participants who respond negatively to any of the above questions are not to be used in the Serviceability Test.

32.2.9 For rearming/serviceability evaluation, test participants qualified in accordance with 32.2.8 shall be informed that they are to be asked to rearm the inflation system they examined and shall be provided with incentive to perform the rearming correctly. They shall also be instructed that they are to be given two rearming kits and that they are free to test one of the kits if they need to do so in order to satisfy themselves that they can perform the rearming procedure properly. The participants shall be instructed that the rearming trial is completed when they present what they believe to be a properly rearmed device (which they have not actuated). Each test participant shall then be given the manufacturer's instructions to be provided with each device (written, pictogram, video, etc.), two rearming kits, and access to the manufacturer's toll-free telephone number when provided. The test participant shall then be instructed to proceed with the rearming evaluation.

32.3 Automatic operability test – automatic and manual-auto inflation systems

32.3.1 Each automatic or manual-auto inflator is to be conditioned as a complete unit (with flanges, valves, water sensing elements, and similar materials in place) and without a cylinder being fitted. For Exposures 7a, 7b, and the last cold cycle of 7c, the largest intended cylinder is to be conditioned for at least one h prior to the test in 32.3.4.

Exception: Water sensing elements are not to be exposed to the following conditions:

a) Weathering;

b) 0.5 percent detergent in "0" hardness water; or

c) 720 h salt spray

32.3.2 Following the conditionings, each sample is to be fitted with a new cylinder of the largest size specified by the inflation system manufacturer.

32.3.3 Other than as specified in the Exception to 32.3.1, a conditioned water sensing element is to be used for each of the trials.

Exception No. 1: When the water sensing element exposed to ASTM Reference Fuel B does not perform as required by 32.3.5, the elements for this trial are to be replaced with new, unconditioned elements and the marking specified in 33.4 applies.

Exception No. 2: When the water sensing element exposed to IRM 902 (Calumet Oil No. 2) does not perform as required by 32.3.5, the elements for this trial are to be replaced with new, unconditioned elements and the marking specified in 33.4 applies.

32.3.4 The samples are to be tested by dropping into water that is no more than 10 inches (25.4 cm) deep. Samples from the high temperature and low temperature exposures are to be tested within 30 s of removal from the exposures. Half of the samples are tested in fresh water and half in 5 percent w\v salt water. The water temperature is to be 20 ±2°C (68 ±4°F), except for the cold temperature exposure, the water temperature is to be 0 +2°C (32 +4°F).

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

32.4 Conditioning test – cylinder seal indicating cylinders

32.4.1 Each cylinder seal indicating cylinder is to be conditioned under the exposures described in Table 32.3. For Exposures 7, or 7b and the last cold cycle of 7c, the largest intended cylinder is to be conditioned as part of a manual or automatic inflation system as specified in 32.5.1 or 32.3.1, respectively. The remaining cylinders are to be conditioned independent of an inflation system. The conditioned cylinders are to be used in the corresponding operability, discharge, and humid atmosphere tests for automatic and manual inflation systems, as appropriate, in accordance with Table 32.1 and Table 32.4.

32.5 Manual operability test – manual and manual-auto inflation systems

32.5.1 Each manual or manual-auto inflator is to be conditioned as a complete unit (with flanges, valves, etc., in place) and without a cylinder fitted. For Exposure 7, the largest intended cylinder is to be conditioned for at least one h prior to the test in 32.5.5.

32.5.2 The test specified in 32.5.5 is to be conducted three times for each sample for each conditioning, each time using a new cylinder of the largest size specified by the inflation system manufacturer.

Exception: Manual-auto inflation systems which have been subjected to the automatic systems Operability Tests are tested with the use of cylinder head blanks, when the average force required to puncture five blanks is equal to or greater than the average force required to puncture the cylinder in the three trials for the Standard Conditioning samples as specified in 32.5.5.

32.5.3 Samples from Exposures 6 and 7 are to be tested as specified in 32.5.5 within 30 s of removal from the exposures.

32.5.4 When the sample uses an expendable element such as a tab, clip or pin each trial is to be with the use of that element.

32.5.5 The sample is to be attached to a rigid fixture. Using a Constant-Rate-of-Extension tensile test machine with readability to 0.1 lbf (0.45 N), a force is to be applied to the pull cord in the intended direction of operation at a rate of 5 ±0.5 inches/min (127 ±12.7 mm/min) until complete puncturing of the cylinder has occurred. The force required to result in puncturing shall be as specified in Table 32.4.

32.6 Operability test – oral systems

32.6.1 Each oral inlet valve is to be conditioned in an unsealed oral tube without an inflatable bladder attached.

32.6.2 Following the conditionings, a gradually increasing air pressure is to be applied to the valve at a rate of 0.5 psi per min (3.5 kPa/min). The pressure at which the valve begins to open (the crack pressure) shall be not more than as specified in Table 32.5.

32.6.3 An air pressure of 1 psig (7 kPa gauge) is then to be applied to the valve. The air flow through the system (i.e., valve and tube) shall be not less than 100 lpm (26.1 gpm).

32.7 Discharge test – automatic, manual-auto, and manual inflation systems

32.7.1 Each inflator from the Operability Tests is to be fitted with an inflatable bladder (made of neutrally buoyant material) with an internal volume that holds the inflation medium from the largest size cylinder specified by the manufacturer without full inflation of the bladder. When required, an alternative method to secure the bladder is by using a new bladder flange piece. However, all other parts of the inflatable

assembly (i.e., valve) are to be those conditioned and used in the Operability Tests, except a water sensing element is not to be put in place.

32.7.2 Each inflator with bladder is to be evacuated of air under a vacuum of at least 10 inches (254 mm) of water.

32.7.3 The combined in-water weight of the evacuated inflator with bladder, an unattached fully charged cylinder, and, for automatic or manual-auto inflators, an expended water sensing element (unassembled), is to be measured to the nearest ounce.

32.7.4 The fully charged cylinder is to be dried and weighed to the nearest 0.1 grams.

32.7.5 The test sample is to be assembled using the evacuated bladder, the inflator, and the cylinder after they have been dried and, for automatic or manual-auto inflators, with a water sensing element as described in 32.3.3. For Exposure 6, 7b (automatic inflation systems), and 7 (manual inflation systems) the assembled test sample is to be reconditioned for at least 1 h prior to the test in 32.7.9 or 32.7.10. These samples are to be tested within 30 s of removal from the exposures.

32.7.6 A dead-weight is then to be attached to the sample in a manner that does not reduce the volume of the inflatable bladder. The in-water weight of the dead-weight is to be as follows:

$$W_i = A - W$$

in which:

W_I = In-Water Weight of dead weight;

A = weight for Exposures 1 – 6, and 8 is 150 N (33.71 lbf) for Use Codes 1F and 2F or 100 N (22.5 lbf) for Use Code 3F. "A" weight for Exposure 7b in Table 32.1 and for Exposure 7 in Table 32.4 is 75 N (16.86 lbf) for Use Codes 1F and 2F or 50 N (11.25 lbf) for Use Code 3F; and

W = Weight determined from 32.7.3.

32.7.7 A test tank of fresh water of such depth as to totally submerge the test sample and bladder is to be used. The temperature of the water in the test tank is to be 20 ±2°C (68±4°F) for Exposures 1 – 6, and 8, and 0 +2°C (32 +4°F) for Exposure 7b (automatic inflation systems and 7 (manual inflation systems). The atmospheric pressure is to be 14.7 ±0.2 psi (760 ±5 mmHg), or the in-water weight of the dead-weight is to be corrected as follows:

$$W_C = W_i \times \frac{P}{14.7\,psi} \times \frac{527.69°R}{T + 429.69}$$

in which:

W_C = Corrected weight;

W_I = In-water weight of dead-weight;

P = Atmospheric pressure in psi; and

T = Temperature in degrees F.

32.7.8 The test sample and weight are then to be dropped into the test tank.

32.7.9 For automatic inflators or the automatic evaluation on an manual-auto inflator, the time interval between the sample entering the water and the audible piercing of the cylinder (the actuation time) shall be not more than 5 s. For manual inflators or the manual evaluation of an manual-auto inflator, the lanyard is to be pulled to puncture the cylinder.

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

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

32.7.12 If completeness of discharge as specified in 32.7.10 and 32.7.11 is not attained within the specified time, then the cylinder is to be removed, dried, and reweighed. If the difference between the preweight in 32.7.4 and this weight is less than the minimum design charge value for the cylinder (indicating that the cylinder was under-charged), then the trial is to be repeated using a new cylinder and, if necessary, a new water sensing element.

32.8 Parallel and perpendicular strength of attachment – automatic, manual-auto, manual, oral inflation systems, and over-pressure relief valve systems

32.8.1 The system is to be attached to a piece of inflation chamber material that complies with this standard using the system manufacturer's attachment instructions.

32.8.2 To secure the joint during application of the load, a rigid adaptor having an inside diameter at least 0.75 inch (19 mm) larger then the outside diameter of the inflator at the point of attachment is to be used.

32.8.3 The adapter is to be attached to a hoist and the required load attached to the main body of the inflation system. The load is then to be raised clear of the floor for the required duration.

32.9 Humid atmosphere test – automatic and manual-auto inflation systems

32.9.1 When tested as specified in 32.9.2 , an automatic or manual-auto inflation system shall perform as required in Table 32.1. Following exposure, the system shall operate as intended.

32.9.2 Automatic or manual-auto inflation systems are to be armed with new water sensing elements and loaded with a proof disc in a proof disc holder, conditioned under Standard Conditions for 24 h and then subjected to the humid atmosphere exposure. Following the exposure, each system that did not actuate during the exposure, is to be tested as follows:

a) The proof disc is to be as follows:

Material	MS 63
Material Number:	2.0321
Thickness:	0.40 ±.02 mm
Diameter:	6.0 +0, -.1 mm
Tensile Strength:	approx. 350 N/mm^2

0.2% Ultimate Strength:	min. 200 N/mm^2
Breaking Strength:	A_5min. 28%; A_{10}min. 24%
Density:	8.4 g/cc

Composition CuZn37: mass in %

CU	62 – 64%
Al	max. 0.03
Fe	max. 0.1
Ni	max. 0.3
Pb	max. 0.1
Sn	max. 0.1
others	max. 0.1
Zn	remainder

Minimum piercing force (P_{min}) and a minimum work to pierce (W_{min}), based on testing of 100 discs from the test lot, with domed side up, using the CO_2 cylinder piercing test procedure in 32.13 and the disc holder in 32.9.1(b) shall be as follows:

For Piercing Force: $P_{min} = x - 3s_x \geq 58.3$ lbf (260 N)

For Work to Pierce: $W_{min} = x - 3s_x \geq 3.1$ in-lbf (0.35 J)

where: x = the mean value for the disc, and

s_x = the standard deviation for the disc value

b) The standard proof disc is to be inserted into a proof disc holder with the domed side up. The proof disc holder is to have a 0.38 mm (0.015 inch) deep 6 mm (0.236 inch) diameter recess to center and hold the proof disc over a 3.4 mm (0.135 inch) diameter pierce pin cavity. The holder is to be threaded to fit the inflation system under test. The holder shown in Figure 32.1 meets the intent of the requirement. For cylinder seal indicating cylinders that contain the pierce pin, the cylinder head is to be modified to hold the standard proof disc in a similar manner.

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

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

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

32.9.3 A manual/auto inflation system without cylinder seal indicator that meets a humid atmosphere level of 49°C (120°F) at 80 ±2 percent relative humidity shall be rated with a Use Code 6F for use with Type V PFDs which comply with the requirements in Standard for Fully Inflatable Recreational Personal Flotation Devices,UL 1180.