

WITHDRAWN NBS Voluntary Product Standard

PS 47-71

A UNITED STATES
DEPARTMENT OF
COMMERCE
PUBLICATION



Heat Shrinkable Fluorocarbon Plastic Tubing

A Voluntary Standard
Developed by Producers,
Distributors, and Users
With the Cooperation of the
National Bureau of Standards

U.S.
DEPARTMENT
OF
COMMERCE

National
Bureau
of Standards

UNITED STATES DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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Voluntary Product Standard
PS 47-71

Heat-Shrinkable Fluorocarbon
Plastic Tubing

Technical Standards Coordinator: L. H. Breden

Abstract

This Voluntary Product Standard covers commercially available PTFE and FEP plastic tubing which can be reduced to a predetermined inside diameter by the application of heat. Included are requirements and methods of test for materials, dimensions, and physical and electrical properties. A method for identifying products which comply with this standard is provided.

Key words: FEP heat-shrinkable tubing; fluorocarbon plastic heat-shrinkable tubing; plastic tubing, fluorocarbon; PTFE heat-shrinkable tubing; tubing, heat-shrinkable fluorocarbon plastic.

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VOLUNTARY PRODUCT STANDARDS

Voluntary Product Standards are standards developed under procedures established by the Department of Commerce (15 CFR Part 10, as amended, May 28, 1970). The standards may include (1) dimensional requirements for standard sizes and types of various products, (2) technical requirements, and (3) methods of testing, grading, and marking. The objective of a *Voluntary Product Standard* is to establish requirements which are in accordance with the principal demands of the industry and, at the same time, are not contrary to the public interest.

Development of a VOLUNTARY PRODUCT STANDARD

The Office of Engineering Standards Services of the National Bureau of Standards has been assigned by the Department of Commerce the responsibility to work closely with scientific and trade associations and organizations, business firms, testing laboratories, and other appropriate groups to develop *Voluntary Product Standards*. The Bureau has the following role in the development process: It (1) provides editorial assistance in the preparation of the standard; (2) supplies such assistance and review as is required to assure the technical soundness of the standard; (3) acts as an unbiased coordinator in the development of the standard; (4) sees that the standard is representative of the views of producers, distributors, and users or consumers; (5) seeks satisfactory adjustment of valid points of disagreement; (6) determines the compliance with the criteria established in the Department's procedures cited above; and (7) publishes the standard.

Industry customarily (1) initiates and participates in the development of a standard; (2) provides technical counsel on a standard; and (3) promotes the use of, and support for, the standard. (A group interested in developing a *Voluntary Product Standard* may submit a written request to the Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234.)

A draft of a proposed standard is developed in consultation with interested trade groups. Subsequently, a Standard Review Committee is established to review the proposed standard. The committee, appropriately balanced, includes qualified representatives of producers, distributors, and users or consumers of the product being standardized. When the committee approves a proposal, copies are distributed for industry consideration and acceptance. When the acceptances show general industry agreement, and when there is no substantive objection deemed valid by the Bureau, the Bureau announces approval of the *Voluntary Product Standard* and proceeds with its publication.

Use of a VOLUNTARY PRODUCT STANDARD

The adoption and use of a *Voluntary Product Standard* is completely voluntary. *Voluntary Product Standards* have been used most effectively in conjunction with legal documents such as sales contracts, purchase orders, and building codes. When a standard is made part of such a document, compliance with the standard is enforceable by the purchaser or the seller along with other provisions of the document.

Voluntary Product Standards are useful and helpful to purchasers, manufacturers, and distributors. Purchasers may order products that comply with *Voluntary Product Standards* and determine for themselves that their requirements are met. Manufacturers and distributors may refer to the standards in sales catalogs, advertising, invoices, and labels on their product. Commercial inspection and testing programs may also be employed, together with grade labels and certificates assuring compliance, to promote even greater public confidence. Such assurance of compliance promotes better understanding between purchasers and sellers.

Heat-Shrinkable Fluorocarbon Plastic Tubing

Effective June 15, 1971 (See section 6.)

(This Standard, initiated by The Society of the Plastics Industry, Inc., has been developed under the *Procedures for the Development of Voluntary Product Standards*, published by the U.S. Department of Commerce. See Section 7, *History of Project*, for further information.)

1. PURPOSE

The purpose of this Voluntary Product Standard is to establish nationally recognized dimensions and significant quality requirements for heat-shrinkable fluorocarbon plastic tubing when made of polytetrafluoroethylene (PTFE) or fluorinated ethylene-propylene (FEP) and intended for chemical, mechanical, or electrical applications. This Standard is also intended to provide producers, distributors, and users with a basis for common understanding of the characteristics of this product.

2. SCOPE AND CLASSIFICATION

2.1. **Scope**—This Voluntary Product Standard covers commercially available PTFE and FEP plastic tubing which can be reduced to a predetermined inside diameter by the application of heat. Included are requirements and methods of test for materials, dimensions, and physical and electrical properties. A method for identifying products which comply with this Standard is provided.

2.2. **Classification**—The plastic tubing covered by this Standard is classified as follows:

Grade A—Tubing made from PTFE resin with a shrink-down temperature in excess of 327 °C (621 °F). Grade A comprises the following types:

- Type I—light-walled tubing
- Type II—standard-walled tubing
- Type III—industrial tubing

Grade B—Tubing made from FEP copolymer resin with a shrink-down temperature in excess of 150 °C (302 °F). There are no subtypes for Grade B tubing.

3. REQUIREMENTS

3.1. **General**—Products represented as complying with this Voluntary Product Standard shall meet all of the requirements specified herein.

3.2. **Material**—Grade A tubing shall be made of PTFE resin conforming to the requirements of the American Society for Test-

ing and Materials (ASTM) D 1457-69, *Standard Specification for TFE-Fluorocarbon Resin Molding and Extrusion Materials*,¹ except that a maximum of 2 percent by weight of additive is permissible.

Grade B tubing shall be made of fluorinated ethylene-propylene (FEP) copolymer resin conforming to the requirements of ASTM D 2116-66, *Standard Specification for FEP-Fluorocarbon Molding and Extrusion Materials*,¹ except that a maximum of 2 percent by weight of additive is permissible.

3.3. Dimensions and tolerances—The dimensions and tolerances of the tubing shall be as specified in tables 1, 2, 3, and 4, when the tubing is measured in accordance with 4.3.

TABLE 1. *Dimensions and tolerances for Grade A, Type I, PTFE plastic heat-shrinkable tubing*

As manu- factured	After unrestricted shrinkage				
	Descriptive size		Inside diameter maximum	Wall thickness	
	American Wire Gage (AWG)	Fractional		Nominal	Tolerance (plus or minus)
inch inside diameter minimum	number	inch	inch	inch	inch
0.029	30	—	0.015	0.009	0.002
.034	28	—	.019	.009	.002
.038	26	—	.022	.009	.002
.045	24	—	.027	.010	.002
.050	22	—	.032	.010	.002
.055	20	—	.040	.012	.003
.060	19	—	.044	.012	.003
.065	18	—	.049	.012	.003
.080	17	—	.054	.012	.003
.090	16	—	.061	.012	.003
.110	15	—	.067	.012	.003
.120	14	—	.074	.012	.003
.130	13	—	.082	.012	.003
.140	12	—	.091	.012	.003
.160	11	—	.101	.012	.003
.180	10	—	.112	.012	.003
.200	9	—	.124	.015	.004
.210	—	1/8	.135	.015	.004
.230	8	—	.140	.015	.004
.240	7	—	.158	.015	.004
.290	6	—	.178	.015	.004
.310	5	—	.198	.015	.004
.370	4	—	.224	.015	.004
.370	3	—	.249	.015	.004
.410	—	1/4	.270	.015	.004
.430	2	—	.278	.015	.004
.450	1	—	.311	.015	.004
.470	—	5/16	.334	.015	.004
.470	0	—	.347	.015	.004
.560	—	3/8	.399	.020	.005
.655	—	7/16	.464	.020	.005
.750	—	1/2	.524	.020	.005
.930	—	5/8	.655	.025	.005
1.125	—	3/4	.786	.030	.006
1.310	—	7/8	.911	.030	.007
1.500	—	1	1.036	.030	.008

¹ Later issues of the ASTM publications referenced in this Standard may be used providing the requirements are applicable and consistent with the issues designated. Copies of ASTM publications are obtainable from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

TABLE 2. Dimensions and tolerances for Grade A, Type II, PTFE plastic heat-shrinkable tubing

As manufactured	After unrestricted shrinkage				
	Descriptive size		Inside diameter maximum	Wall thickness	
	American Wire Gage (AWG)	Fractional		Nominal	Tolerance (plus or minus)
Inside diameter minimum					
<i>inch</i>	<i>number</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>
0.029	30	—	0.015	0.012	0.002
.034	28	—	.019	.012	.002
.038	26	—	.022	.012	.002
.045	24	—	.027	.012	.002
.050	22	—	.032	.012	.002
.055	20	—	.040	.016	.003
.060	19	—	.044	.016	.003
.065	18	—	.049	.016	.003
.080	17	—	.054	.016	.003
.090	16	—	.061	.016	.003
.110	15	—	.067	.016	.003
.120	14	—	.074	.016	.003
.130	13	—	.082	.016	.003
.140	12	—	.091	.016	.003
.160	11	—	.101	.016	.003
.180	10	—	.112	.016	.003
.200	9	—	.124	.020	.004
.210	—	1/8	.135	.020	.004
.230	8	—	.140	.020	.004
.240	7	—	.158	.020	.004
.290	6	—	.178	.020	.004
.310	5	—	.198	.020	.004
.370	4	—	.224	.020	.004
.370	3	—	.249	.020	.004
.410	—	1/4	.270	.020	.004
.430	2	—	.278	.020	.004
.450	1	—	.311	.020	.004
.470	—	5/16	.334	.020	.004
.470	0	—	.347	.020	.004
.560	—	3/8	.399	.025	.006
.655	—	7/16	.464	.025	.006
.750	—	1/2	.524	.025	.006
.930	—	5/8	.655	.030	.006
1.125	—	3/4	.786	.035	.008
1.310	—	7/8	.911	.035	.008
1.500	—	1	1.036	.035	.008

TABLE 3. Dimensions and tolerances for Grade A, Type III, PTFE plastic heat-shrinkable tubing

As manufactured	After unrestricted shrinkage				
	Descriptive size	Inside diameter maximum	Wall thickness		
			Fractional	Nominal	Tolerance (plus or minus)
Inside diameter, minimum					
<i>inch</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>
0.082	1/16	0.067	0.030	0.030	0.005
.166	1/8	.130	.030	.030	.005
.250	3/16	.193	.030	.030	.005
.333	1/4	.257	.030	.030	.005
.415	5/16	.320	.030	.030	.005
.498	3/8	.383	.030	.030	.005
.580	7/16	.448	.030	.030	.006
.666	1/2	.510	.030	.030	.006
.830	5/8	.637	.030	.030	.006
1.000	3/4	.764	.040	.040	.007
1.170	7/8	.891	.045	.045	.007
1.330	1	1.020	.050	.050	.008

TABLE 4. Dimensions and tolerances for Grade B, FEP plastic heat-shrinkable tubing

As manufactured	After unrestricted shrinkage		
Inside diameter, min.	Inside diameter, max.	Wall thickness	
		Nominal	Tolerance (plus or minus)
<i>inch</i>	<i>inch</i>	<i>inch</i>	<i>inch</i>
0.031	0.027	0.008	0.002
.036	.032	.008	.002
.045	.040	.008	.002
.060	.049	.008	.002
.075	.061	.009	.002
.092	.074	.009	.002
.115	.091	.009	.002
.141	.112	.010	.003
.158	.124	.010	.003
.180	.140	.010	.003
.197	.158	.011	.004
.225	.178	.011	.004
.248	.198	.011	.004
.290	.224	.011	.004
.310	.249	.011	.004
.365	.278	.012	.004
.400	.311	.012	.004
.440	.347	.012	.004
.500	.383	.015	.004
.580	.448	.020	.004
.666	.510	.020	.004
.830	.637	.025	.004
1.000	.764	.030	.004
1.170	.891	.035	.004
1.300	1.000	.020	.004
1.330	1.020	.035	.004
1.700	1.300	.020	.004
2.100	1.700	.020	.004
2.600	2.100	.020	.004
3.100	2.600	.020	.004
3.500	3.100	.020	.004
4.300	3.500	.020	.004
5.200	4.200	.020	.004
6.200	4.900	.020	.004
7.200	6.200	.020	.004
8.200	7.200	.020	.004

3.4. Melting point—The tubing shall have a melting point as specified in table 5 when tested in accordance with 4.4.

TABLE 5. Physical properties

Grade	Melting point	Specific gravity	Tensile strength at 200% elongation minimum	Elongation minimum
			<i>psi</i>	<i>percent</i>
Grade A	327 ± 10 °C (621 ± 18 °F)	2.15 to 2.24	2500	200
Grade B	270 ± 20 °C (518 ± 36 °F)	2.14 to 2.17	1500	200

3.5. Specific gravity—The tubing shall have a specific gravity as specified in table 5 when tested in accordance with 4.5.

3.6. Tensile strength and elongation—The tubing shall have a tensile strength and elongation as specified in table 5 when tested in accordance with 4.6.

3.7. Heat resistance—The tubing shall remain flexible and free from cracks and splits when tested in accordance with 4.7.

3.8. Low temperature flexibility—The tubing shall remain flexible and free of cracks when tested in accordance with 4.8.

3.9. Dimensional stability—Grade A tubing shall have a maximum change in length after shrinkage of 20.0 percent when tested in accordance with 4.9. Grade B tubing shall have a maximum change in length after shrinkage of 15.0 percent when tested in accordance with 4.9.

3.10. Dielectric breakdown voltage—Grade A tubing shall have a minimum dielectric breakdown voltage as specified in table 6 when tested in accordance with 4.10. Grade B tubing shall have a minimum dielectric breakdown voltage of 500 volts per mil of thickness when tested in accordance with 4.10.

TABLE 6. Dielectric breakdown voltage

Nominal wall thickness	Dielectric breakdown, minimum
<i>inch</i>	<i>volts</i>
0.007 to 0.0089 inclusive	10,000
0.009 to 0.0099 inclusive	11,500
0.010 to 0.0119 inclusive	12,500
0.012 to 0.0149 inclusive	14,600
0.015 to 0.0159 inclusive	15,000
0.016 to 0.0199 inclusive	16,300
0.020 and higher	17,000

3.11. Color stability—The tubing shall exhibit no significant change in color after heat-aging for 5 hours at 200 ± 2 °C (392 ± 4 °F). This can be determined after completion of the heating cycle described in 4.8. The color of the tubing shall be as agreed upon by purchaser and seller.

4. INSPECTION AND TEST PROCEDURES

4.1. General—The inspection and test procedures contained in this section are to be used to determine the conformance of products to the requirements of this Voluntary Product Standard. Each producer or distributor who represents his products as conforming to this Standard may utilize statistically based sampling plans which are appropriate for each particular manufacturing process but shall keep such essential records as are necessary to document with a high degree of assurance his claim that all of the requirements of this Standard have been met. Additional sampling and testing of the product, as may be agreed upon between purchaser and seller, is not precluded by this section.

4.2. Conditioning—Unless otherwise specified, all tests shall be made on “shrunkdown” tubing, after unrestricted shrinkage. The shrink temperature and time for shrinking shall be as follows:

Grade A material 350 ± 4 °C (662 ± 8 °F) for 10 minutes.
Grade B material 175 ± 2 °C (347 ± 4 °F) for 10 minutes.

4.2.1. Test conditions—The test specimens shall be conditioned and tested in accordance with procedure A of ASTM D 618-61, *Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing*.²

4.3. Dimensions and tolerances—The inside diameter dimensions shall be determined before and after unrestricted shrinkage. Wall thickness measurements shall be made only on “shrunkdown” tubing.

4.3.1. Inside diameter—The inside diameter shall be determined in accordance with ASTM D 1675-65, *Standard Methods of Testing Electrical Grade Polytetrafluoroethylene Tubing*.²

4.3.2. Wall thickness—The wall thickness shall be determined in accordance with the procedures described in ASTM D 1675-65, except that no individual measurement shall exceed the tolerances specified in tables 1, 2, 3, and 4.

4.4. Melting point—The melting point for PTFE tubing shall be determined, using a shaving from the tubing rather than a molded disk, in accordance with section 14 of ASTM D 1457-69. The melting point of FEP tubing shall be determined in accordance with section 12 of ASTM D 2116-66.

4.5. Specific gravity—The specific gravity shall be determined in accordance with method A, ASTM D 792-66, *Standard Methods of Test for Specific Gravity and Density of Plastics by Displacement*.²

4.6. Tensile strength and elongation—The tensile strength and elongation shall be determined as specified in 4.6.1, 4.6.2, 4.6.3, and 4.6.4 on five longitudinal and five transverse specimens using a testing speed of 2 inches per minute. The test results for the longitudinal and the transverse specimens shall be averaged separately. Specimens which break in the jaws of the tensile tester shall be discarded, and new tests shall be made.

4.6.1. Tubing having an inside diameter of 0.625 inch and over—The tensile strength and elongation shall be determined in both the longitudinal and transverse directions in accordance with ASTM D 1457-69.

4.6.2. Tubing having an inside diameter less than 0.625 inch to 0.200 inch inclusive—The tensile strength and elongation shall be determined in the longitudinal direction in accordance with ASTM D 1457-69, and in the transverse direction in accordance with ASTM D 412-68, *Standard Method of Tension Testing of Vulcanized Rubber*.² Transverse specimens shall be ring specimens, ¼ inch long, and shall be cut from tubing using the technique provided for heavy-walled tubing greater than 0.060 inch in thickness in paragraph 4.4.1 of ASTM D 412-68.

² See footnote 1, page 2.

4.6.3. **Tubing having an inside diameter less than 0.200 inch to 0.090 inch inclusive**—The tensile strength and elongation shall be determined in both the longitudinal and transverse directions in accordance with ASTM D 412-68. For longitudinal specimens, the tubing shall be slit parallel to the axis and flattened out, prior to punching out specimens. Specimen shape shall be in the form of a dumbbell as shown in figure 1. Transverse specimens, $\frac{1}{4}$ inch long, shall be discarded, and new tests shall be made.
412-68.

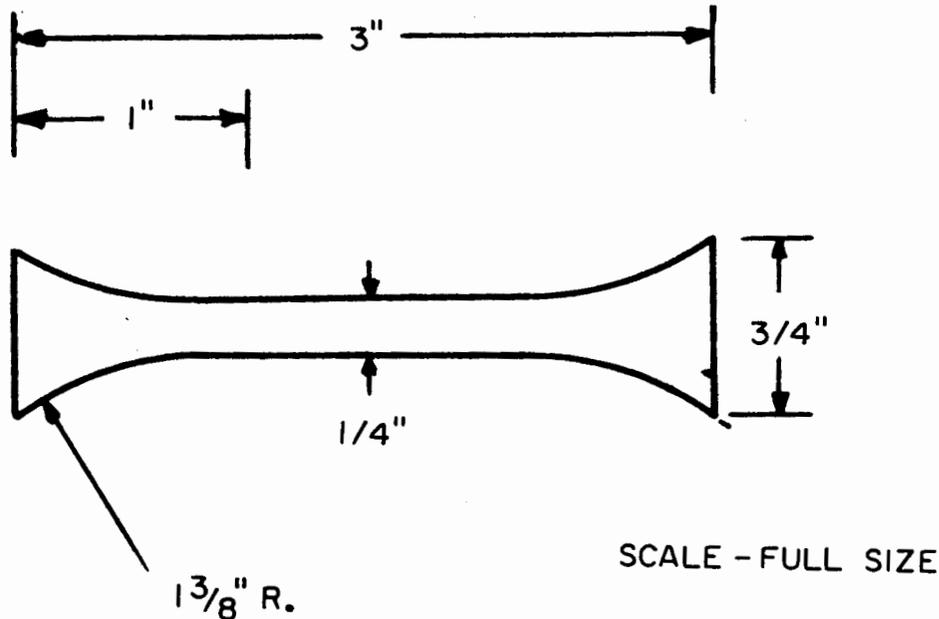


FIGURE 1. *Tensile specimen for tubing 0.200 inches to 0.090 inch inclusive.*

4.6.4. **Tubing having an inside diameter less than 0.090 inch**—Specimens shall be tested as filaments. Nonslip type loop knots shall be made in each end of the specimen so that there are $1\frac{3}{8}$ inches between the knots of the loops (see figure 2). The loops shall be placed over the drum of a standard wire specimen holder in the tensile machine and pulled in this position.

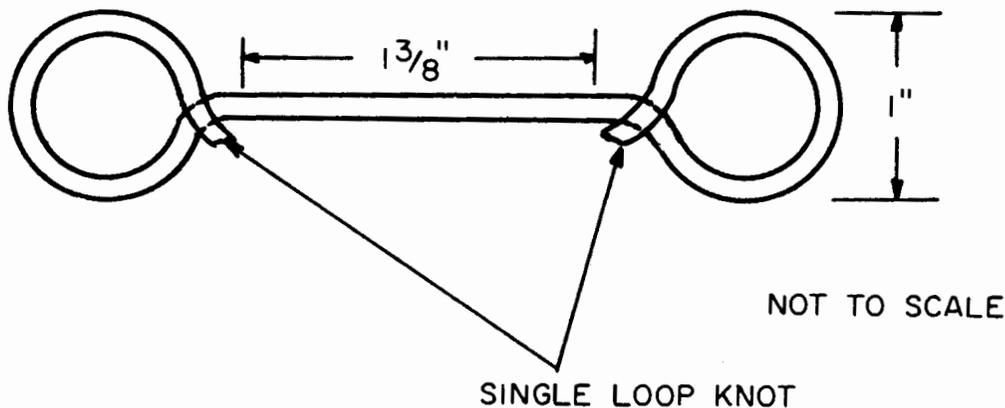


FIGURE 2. *Tensile specimen for tubing less than 0.090 inch.*

4.7. **Heat resistance**—Three specimens of the tubing, each approximately 6 inches long, shall be placed in a circulating-air oven for 96 hours at 350 ± 4 °C (662 ± 8 °F) for Grade A tubing or 200 ± 2 °C (392 ± 4 °F) for Grade B tubing. The specimens are removed from the oven, allowed to cool to room temperature, and examined for cracks or splits. The three specimens shall then be subjected to the low temperature test of 4.8.

4.8. **Low temperature flexibility**—Three specimens, each 12 inches long, shall be placed in a circulating-air oven at 200 ± 2 °C (392 ± 4 °F) for 5 hours, cooled to room temperature, and then conditioned at minus 55 ± 2 °C (-67 ± 4 °F) for 4 hours. A fixed mandrel, selected in accordance with table 7 shall be conditioned at the same temperature. After completion of the conditioning period and while still maintained at the conditioning temperature, the specimens shall be rapidly wrapped about the mandrel for not less than two complete wraps. The speed of wrapping shall be approximately 2 seconds per 360° wrap.

TABLE 7. *Mandrel dimensions for low temperature flexibility*

Inside diameter of tubing	Diameter of mandrel
<i>inch</i>	<i>inch</i>
0.023 to 0.125	$\frac{5}{16}$
0.126 to 0.250	$\frac{3}{8}$
0.251 to 1.000	$\frac{7}{16}$

4.9. **Dimensional stability**—Prior to shrinkage, three cleanly-cut specimens, each 6 inches long, shall be measured to the nearest $\frac{1}{16}$ inch. The specimens shall then be placed in a circulating-air oven for 10 minutes at 350 ± 4 °C (662 ± 8 °F) for Grade A tubing or 175 ± 2 °C (347 ± 4 °F) for Grade B tubing. The specimens are then removed from the oven and allowed to cool for 30 minutes to room temperature. The specimens shall then be placed in a circulating-air oven for 3 hours at 260 ± 5 °C (500 ± 9 °F) for Grade A tubing or 200 ± 2 °C (392 ± 4 °F) for Grade B tubing. The specimens are then removed from the oven and allowed to cool to 23 ± 2 °C (73.4 ± 4 °F). The length is again determined to within $\frac{1}{16}$ inch. The change in length shall be calculated as a percentage of the original length.

4.10. **Dielectric breakdown voltage**—The dielectric breakdown voltage of the tubing shall be determined in accordance with ASTM D 1675-65.

5. IDENTIFICATION

In order that purchasers may identify products conforming to all requirements of this Voluntary Product Standard, producers and distributors may include a statement of compliance in conjunction with their name and address on product labels, invoices, sales literature, and the like. The following statement is suggested when sufficient space is available:

This Grade _____, Type _____, polytetrafluoroethylene (PTFE) [This Grade _____, fluorinated ethylene-propylene

(FEP)] heat-shrinkable plastic tubing conforms to all of the requirements established in Voluntary Product Standard PS 47-71, developed cooperatively with the industry and published by the National Bureau of Standards under the *Procedures for the Development of Voluntary Product Standards* of the U.S. Department of Commerce. Full responsibility for the conformance of this product to the standard is assumed by (name and address of producer or distributor).

The following abbreviated statement is suggested when available space on labels is insufficient for the full statement:

Conforms to PTFE Grade _____, Type _____, [conforms to FEP Grade _____,] in PS 47-71, (name and address of producer or distributor).

6. EFFECTIVE DATE

The effective date of this Voluntary Product Standard is the date upon which reference to the Standard may be made by producers, distributors, users and consumers, and other interested parties. Compliance by producers with all of the requirements of this Voluntary Product Standard may not actually occur until some time after its effective date. Products shall not be represented as conforming to this Voluntary Product Standard until such time as all requirements established in the Standard are met. The effective date of this Standard is June 15, 1971.

7. HISTORY OF PROJECT

In July 1968, The Society of the Plastics Industry, Inc., requested the assistance of the Department of Commerce in establishing a Voluntary Product Standard for heat-shrinkable fluorocarbon plastic tubing. A proposed draft of the Standard was developed, and in October 1970, the proposed Standard was approved by the Standard Review Committee. In December 1970, public announcement was made, and the recommended Voluntary Product Standard was widely circulated to the industry for acceptance. The response to this circulation indicated a consensus of acceptability within the industry as defined in the *Procedures for the Development of Voluntary Product Standards*. Accordingly, the Standard, designated PS 47-71, *Heat-Shrinkable Fluorocarbon Plastic Tubing*, was approved for publication by the National Bureau of Standards to be effective June 15, 1971.

Technical Standards Coordinator:

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8. STANDING COMMITTEE

The individuals whose names are listed below constitute the membership of the Standing Committee for this Standard. The function of the committee is to review all proposed revisions and amendments in order to keep this Standard up to date. Comments concerning this Standard and suggestions for its revision may be addressed to any member of the committee or to the Office of

Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234, which acts as secretary for the committee.

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The producers, distributors, users, and others listed below have individually indicated in writing their acceptance of this Voluntary Product Standard prior to its publication. The acceptors have indicated their intention to use this Standard as far as practicable but reserve the right to depart from it when necessary. The list is published to show the extent of recorded public support for this Standard.

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