

MILITARY SPECIFICATION
INSULATION TUBING, ELECTRICAL,
POLYTETRAFLUOROETHYLENE RESIN, NONRIGID

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 This specification covers nonrigid polytetrafluoroethylene resin tubing for electrical insulating purposes.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

VV-I-530 - Insulating Oil, Electrical (for Transformers, Switches, and Circuit Breakers).

STANDARDS

MILITARY

MIL-STD-104 - Limits for Electrical Insulation Color.

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

AMERICAN SOCIETY FOR TESTING MATERIALS STANDARDS.

D876 - Methods of Testing Nonrigid Vinyl Chloride Polymer Tubing (Tentative) - 60T.

D1675 - Testing Electrical Grade Polytetrafluoroethylene Tubing (Tentative) 59T.

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.)

OFFICIAL CLASSIFICATION COMMITTEE

Uniform Freight Classification Rules.

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York 16, N. Y.)

3. REQUIREMENTS

3.1 Material. - The tubing shall be made of polytetrafluoroethylene resin.

3.1.1 Uniformity. - All tubing in each lot shall be uniform in texture, color, and finish.

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3.1.2 Defects.- The tubing shall be clean, smooth, and free from foreign material (except pigments when colored), and from imperfections detrimental to fabrication, appearance, or performance of parts

3.1.3 Color.- Unless otherwise specified (see 6.2), the tubing shall be natural in color. Natural tubing can vary from a water white to a straw yellow and range in transparency from translucent to opaque. Colored tubing shall conform to Standard MIL-STD-104.

3.2 Property values.- The tubing shall conform to the property values specified in table I.

3.3 Dimensions and tolerances.-

3.3.1 Lengths.- Unless otherwise specified, the footage of tubing on a reel or in a coil shall conform to table II (see 6.2).

3.3.2 Inside diameters and wall thicknesses.- Unless otherwise specified, tubing shall be furnished in the standard inside diameters and wall thicknesses shown in table III as specified (see 6.2).

3.3.3 Concentricity.- The minimum percent concentricity of the tubing, when determined as specified in 4.5.2, shall be 70 percent.

3.4 Workmanship.- The material shall be manufactured and processed in a careful and workmanlike manner, in accordance with good practice.

Table I - Property values for tubing.

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Value required
Dielectric breakdown ^{1/}	4.5.3	C-96/23/0	Volts (min.)	Inch wall thick- 0.009 .012 .016 .020	11,500 14,600 16,300 17,000
Dielectric breakdown Variability	4.5.3	C-96/23/0	Percent (max.)	All thick- nesses	30
Dielectric Breakdown ^{1/}	4.5.3	C-96/23/96	Percent of dry value obtained on test (min.)	All thick- nesses	85
Lengthwise shrinkage	4.5.4	E-2/300	Percent (max.)	---	1
Stress at 200 percent elongation ^{2/}	4.5.5	C-96/23/50	P.s.i. (max.) P.s.i. (min.)	--- ---	6,000 2,500

^{1/}For thickness not shown, the dielectric breakdown shall be that given for the nearest thickness shown.

^{2/}Each of the five specimens shall elongate at least 200 percent, otherwise, the material shall be considered as failing to conform to the specification.

Table II - Tubing lengths.

AWG size number	Minimum length in feet per reel	Minimum length in feet per coil
30 to 22, inclusive	1,000	---
20 to 17, inclusive	500	---
16 to 11, inclusive	200	---
10 to 0, inclusive	----	100

^{1/}The shortest piece in the coil shall not be less than 3 feet in length.

4. QUALITY ASSURANCE PROVISIONS

4.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Sampling for acceptance inspection.

4.2.1 Lot. - A lot of tubing shall consist of all tubing of the same size offered for delivery at the same time.

4.2.2 Sampling for visual and dimensional examination. - Sample reels or coils of tubing shall be selected in accordance with Standard MIL-STD-105 at inspection level II from each lot for the visual and dimensional examination specified in 4.3.1.

Table III - Inside diameters and wall thicknesses of tubing (AWG sizes).

AWG size number	Inside diameter (inches)		Wall thickness (inches)		
	Minimum	Maximum	Minimum	Maximum	Nominal
30	0.010	0.015	0.007	0.011	0.009
28	.013	.019	.007	.011	.009
26	.016	.022	.007	.011	.009
24	.020	.027	.010	.014	.012
22	.025	.032	.010	.014	.012
20	.039	.040	.013	.019	.016
19	.043	.044	.013	.019	.016
18	.040	.049	.013	.019	.016
17	.045	.054	.013	.019	.016
16	.051	.061	.013	.019	.016
15	.057	.067	.013	.019	.016
14	.064	.074	.013	.019	.016
13	.072	.082	.013	.019	.016
12	.081	.091	.013	.019	.016
11	.091	.101	.013	.019	.016
10	.102	.112	.013	.019	.016
9	.114	.124	.016	.024	.020
8	.120	.130	.016	.024	.020
8	.129	.141	.016	.024	.020
7	.144	.158	.016	.024	.020
6	.162	.178	.016	.024	.020
5	.182	.198	.016	.024	.020
4	.204	.224	.016	.024	.020
3	.229	.249	.016	.024	.020
2	.250	.260	.016	.024	.020
2	.258	.278	.016	.024	.020
1	.289	.311	.016	.024	.020
0	.325	.347	.016	.024	.020

4.2.3 Sampling for acceptance tests. - Three sample reels or coils shall be selected from each lot for tests as specified in 4.3.2. The minimum quantity taken from each sample reel or coil shall be 32 feet.

4.3 Acceptance inspection.

4.3.1 Visual and dimensional examination. - Each sample selected in accordance with 4.2.2 shall be visually and dimensionally examined to verify conformance with the requirements in 3.1, 3.3 and 3.4. Any reel or coil having one or more defects shall be rejected. If the number of defective samples exceeds the acceptable number for the appropriate sampling plan of Standard MIL-STD-105 at acceptance quality level (AQL) 2.5 percent, the lot represented by the samples shall be rejected.

4.3.2 Acceptance tests. - The three samples selected in accordance with 4.2.3 shall be subjected to the tests specified in table IV. Results shall be averaged for each sample to determine conformance with this specification. If one or more of the samples fail one or more of the tests, the entire lot shall be rejected.

4.3.3 Reports of acceptance inspection. - Three copies of the acceptance inspection report shall be forwarded to the bureau or agency concerned.

4.4 Conditioning. - The tubing shall be conditioned before being tested, as specified in table I.

4.4.1 Equipment. - Conditioning chambers and baths shall be such as to maintain the specified temperature plus or minus 2°C. and the specified relative humidity plus or minus 2 percent.

4.4.2 Designation. - Conditioning procedures shall be designated as follows:

- (a) A capital letter indicating the general condition of the specimen; that is, humidity, immersion, and temperature conditioning.
- (b) A number indicating in hours the duration of the conditioning.
- (c) A number indicating in degrees centigrade the conditioning temperature.
- (d) A number indicating relative humidity whenever relative humidity is controlled. (Relative humidity obtained over calcium chloride shall be taken as zero.)

Table IV - Acceptance tests.

Test	Requirement reference	Test reference	Conditioning prior to test (see 4.4)	Minimum number of test specimens per sample
Dielectric breakdown	3.2	4.5.3	C-96/23/0 C-96/23/96	10 10
Lengthwise shrinkage	3.2	4.5.4	E-2/300	3
Stress at 200 percent elongation	3.2	4.5.5	C-96/23/50	5

4.4.2.1 The numbers shall be separated from each other by slant marks, and from the capital letter by a dash.

4.4.3 Nomenclature. - The following letters shall be used to indicate the respective general conditioning:

Condition C - The specimens shall be conditioned for the time and at the temperature and relative humidity specified.

Examples:

C-96/23/0 - 96 hours, 23°C., 0 percent relative humidity (desiccation over calcium chloride).

C-96/23/50 - 96 hours, 23°C., 50 percent relative humidity.

C-96/23/96 - 96 hours, 23°C., 96 percent relative humidity.

Condition E - The specimens shall be conditioned for the time and at the temperature specified.

Example:

E-2/300 - 2 hours, 300°C.

4.5 Methods of examination and tests. - The methods of examination and tests shall be as specified in 4.5.1 to 4.5.5, inclusive. Unless otherwise specified herein, all methods shall be conducted under room conditions (23 ± 2°C., 50 ± 2 percent relative humidity).

4.5.1 Inside and outside diameters and wall thickness. -

4.5.1.1 Size number 23 and larger inside diameter. - The inside diameter, the outside diameter, and wall thickness of the tubing shall be determined in accordance with the method specified in ASTM D876 or ASTM-D1675-59T. The inside diameter, however, may be determined by measuring the diameter of the mandrel adjacent to the edge of the tubing specimen by use of a chisel point micrometer. The inside

diameter, the outside diameter, and wall thickness shall be measured at a minimum of 10 representative points along the length of the sample. At each point three measurements approximately 120 degrees apart shall be made of the outside diameter. The average inside diameter and outside diameter shall be reported, and the average wall thickness shall be reported as one-half the difference of the two averages.

4.5.1.2 Size number 24 and smaller inside diameter.- The inside diameter, the outside diameter, and wall thickness of the tubing shall be determined by making use of a toolmaker's microscope or a comparator using reflected light which will measure the dimensions to within plus or minus 0.0001 inch. A magnification of 40 times or more is recommended. The inside diameter, the outside diameter, and wall thickness shall be measured at a minimum of 10 representative points along the length of the sample. At each point three measurements approximately 120 degrees apart shall be made of the inside and outside diameters. The average inside diameter and outside diameter shall be reported, and the average wall thickness shall be reported as one-half the difference of the two averages.

4.5.2 Concentricity.- Concentricity measurements shall be made, employing a toolmaker's microscope, by determining the maximum and minimum wall thickness of five cross sections of individual tubing specimens obtained by cutting perpendicular to the longitudinal axis of the tubing at five representative points along the length of the tubing. The concentricity of each specimen shall be calculated using the following formula and the average of all specimens shall be determined:

$$C = \frac{T \text{ min.}}{T \text{ max.}} \times 100$$

Where:

- C = concentricity, in percent.
- T min = minimum wall thickness, in inches.
- T max = maximum wall thickness, in inches.

4.5.3 Dielectric breakdown.-

4.5.3.1 Test equipment.- The test equipment shall consist of a high voltage transformer rated at not less than 2 kilovolt-amperes and the necessary auxiliary equipment for applying, controlling, and measuring the test voltage. The power supply shall consist of an alternating-current source having as nearly a true sine wave as possible at a frequency not exceeding 100 cycles per second.

4.5.3.2 Voltage control.- The high-tension voltage taken from the secondary of the testing transformer shall be capable of being raised gradually from any point at a rate of 500 volts per second. The control may be made with an induction regulator, a variable ratio autotransformer, or by generator-field regulation. Any method of controlling the voltage which does not distort the wave more than 10 percent from a sinusoidal shape is satisfactory.

4.5.3.3 Voltage measurement.- The voltage shall be measured by any method which gives root-mean-square values, preferably by means of a voltmeter connected to a tertiary coil or to the secondary of a separate step-down instrument potential transformer. An electrostatic voltmeter in the high tension circuit is also satisfactory. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of the transformation does not change under any test condition.

4.5.3.4 Test electrodes. The inner electrode shall be a solid copper conductor or wire which fits the inside of the tubing closely without stretching the tubing. A strip of metal foil shall be used as the outer electrode. The strip shall be 1 inch in width and approximately 0.0005 inch in thickness. The length shall be such that three complete turns can be made with a 1/2-inch free end for electrical connections.

4.5.3.5 Specimens.- Pieces 12 inches long shall be cut. Each of the pieces shall be cut in half cross-wise to obtain the test specimens. One half of each piece shall be tested after Condition C-96/23/0. The other half of each piece shall be tested after Condition C-96/23/96.

4.5.3.6 Procedure.-

4.5.3.6.1 Tests shall be made within 5 minutes after removal from conditioning. The specimen shall be immersed in transformer oil conforming to Specification VV-I-530 and maintained at $23^{\circ} \pm 1^{\circ}\text{C}$. The oil shall be changed frequently to prevent excessive deterioration. The inner test electrode shall be kept clean and polished. The outer metal foil electrode shall be centered on the length of the specimen and shall be discarded after each test.

4.5.3.6.2 Starting at zero, the voltage shall be increased to a breakdown at a uniform rate of 500 volts per second. The average dielectric breakdown for a tested sample, denoted "X" shall be the number determined by dividing the sum of the individual specimen dielectric breakdown readings by ten (the number of specimens for the sample tested). Expressed in equation form:

$$\bar{X} = \frac{\sum X_i}{10}$$

Where: \bar{X} = average dielectric breakdown in volts.

$\sum X_i$ = sum of individual dielectric breakdown readings in volts.

4.5.3.6.3 The dielectric breakdown variability of material tested after condition C-96/23/0 shall be calculated by means of the following formula:

$$V = \frac{100}{\bar{X}} \left[\frac{\sum X^2 - \frac{(\sum X)^2}{10}}{9} \right]^{1/2}$$

Where V = dielectric breakdown variability, in percent.

\bar{X} = mean dielectric breakdown, in volts.

X = individual dielectric breakdown reading, in volts.

4.5.4 Lengthwise shrinkage. -

4.5.4.1 Specimens. - Full section tubing in lengths of 6 inches with 5 inches between bench marks shall be tested.

4.5.4.2 Procedure. - The specimens shall be supported by insertion of a solid conductor having a diameter equal to the minimum diameter of the next smallest size of tubing listed in table III. The specimens so supported shall be held horizontally in an oven and subjected to condition E-2/300. The specimens shall then be removed and cooled to room temperature (23 °C.) for 2 hours. The length of the material shall be measured before and after heating, and the percent shrinkage calculated from these values.

4.5.5 Stress at 200 percent elongation. -

4.5.5.1 Test equipment. - The stress at 200 percent elongation shall be determined on an approved pendulum type or constant rate of elongation testing machine. The machine shall be power-driven.

4.5.5.2 Procedure. - The stress-strain characteristics shall be measured on five specimens conditioned at C-96/23/50. Specimens shall be cut 5 inches long, bench marked 2 inches apart, set in the tensile machine with clamp jaws set 2-1/2 inches apart, and stressed at a rate of jaw separation of 12 inches per minute. Stress shall be recorded at 200 percent elongation.

4.6 Inspection of preparation for delivery. - Sample packages and packs shall be tested for compliance with section 5.

5. PREPARATION FOR DELIVERY

5.1 Domestic shipment and early equipment installation and for storage of shipboard repair parts. -

5.1.1 Insulation tubing, electrical. -

5.1.1.1 Preservation and packaging. - Preservation and packaging shall be sufficient to afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the using activity, and until early installation.

5.1.1.2 Packing. - Packing shall be accomplished in a manner which will insure acceptance by common carrier and will afford protection against physical or mechanical damage during direct shipment from the

supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation.

5.1.1.3 Marking.- Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, Federal stock number or manufacturer's part number, contract or order number, contractor's name and destination.

5.2 Domestic shipment and storage or overseas shipment. - The requirements and levels of preservation, packaging, packing and marking for shipment shall be specified by the procuring activity (see 6.2).

(5.2.1 The following provides various levels of protection during domestic shipment and storage or overseas shipment, which may be required when procurement is made by a Government activity (see 6.2).

5.2.1.1 Packaging -

5.2.1.1.1 Level A. - Tubing furnished on reels or in coil form shall be processed as follows:

5.2.1.1.1.1 Reels. - Reels shall be individually wrapped in not less than 30-pound basic weight kraft paper and securely sealed with minimum 2-inch wide tape conforming to Specification UU-T-116. The tape shall be applied in such lengths that it will completely encircle the reel and lap itself at least 2 inches.

5.2.1.1.1.2 Coils.- Coils shall be completely wrapped with kraft paper and secured by taping, tying, or other suitable means.

5.2.1.1.1.3 Alternatively, reels of tubing may be individually packaged in a plastic film bag. Bag closure shall be effected by heat sealing, adhesive, or other suitable means.

5.2.1.1.1.4 Unit containers.- Reels or coils shall be further packaged in folding or set-up paperboard or fiber boxes conforming to Specification PPP-B-566, PPP-B-676, or PPP-B-636, respectively, at the option of the contractor. Box closure shall be as specified in the applicable box specification or appendix thereto.

5.2.1.2 Packing -

5.2.1.2.1 Level A.- Reels and coils of tubing, packaged as specified (see 6.2), shall be packed in overseas type, wood-cleated fiberboard, nailed wood, wirebound wood, fiber, wood-cleated veneer paper overlaid, or wood-cleated plywood boxes conforming to Specification PPP-B-591, PPP-B-621, PPP-B-585, PPP-B-636 (class 2), PPP-B-576, or PPP-B-601, respectively, at the option of the contractor. Unless otherwise specified (see 6.2), shipping containers shall have case liners conforming to Specification MIL-L-10547, and shall be closed and sealed in accordance with the appendix thereto. Case liners for boxes conforming to Specification PPP-B-636 may be omitted, provided all center and edge seams and manufacturer's joint are waterproofed with tape in accordance with the appendix to Specification PPP-B-636. Boxes shall be closed and strapped in accordance with the applicable box specification or appendix thereto. The gross weight of wood or wood-cleated boxes shall not exceed 200 pounds; fiber boxes shall not exceed the weight limitations of the applicable box specification.

5.2.1.2.2 Level B. - Reels or coils of tubing, packaged as specified (see 6.2), shall be packed in domestic type wood-cleated fiberboard, nailed wood, wirebound wood, cleated plywood or wood-cleated veneer paper overlaid boxes or class 1 fiber boxes conforming to Specification PPP-B-591, PPP-B-621, PPP-B-585, PPP-B-601, PPP-B-576, or PPP-B-636, respectively, at the option of the contractor. Box closures shall be as specified in the applicable box specification or appendix thereto. The gross weight of wood or wood cleated boxes shall not exceed 200 pounds; fiber boxes shall not exceed the weight limitations of the applicable box specification.

5.2.1.2.2 Level C.- Reels or coils of tubing, packaged as specified (see 6.2), shall be packed in containers which will insure acceptance by common carrier and safe delivery at destination. Shipping containers shall comply to the Uniform Freight Classification Rules or other regulations as applicable to the mode of transportation.

5.2.1.3 **Marking.** - In addition to any special marking required by the contract or order, or herein, interior and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129.)

6. NOTES

6.1 **Intended use.** - The tubing covered by this specification is intended for applications involving high temperature, high frequencies, or both. Tubing covered by this specification possesses excellent electrical properties which remain practically constant over a wide range of frequencies, temperatures, and humidities, and has a very low loss factor. Except in well defined special applications the tubing should not be used at temperatures in excess of 275 °C.

6.2 **Ordering data.** - Procurement documents should specify the following:

- (a) Title, number, and date of this specification
- (b) Color, if required (see 3.1.3).
- (c) Dimensions required (see 3.3):
 - (1) Number of feet required
 - (2) Number of feet in single reel or coil (see 3.3.1).
 - (3) AWG size number (see 3.3.2).
 - (4) Nominal wall thickness (see 3.3.2).
- (d) Preservation, packaging, packing, or marking requirements other than those required by 5.1 (see 5.2).
- (e) Whether shipping containers shall have case liners (see 5.2.1.2.1).

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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