

Submitted for recognition as an American National Standard

Insulation Sleeving, Electrical, Flexible

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1. SCOPE:

1.1 Scope:

This specification covers flexible extruded, vinyl plastic tubing.

1.2 Classification:

The insulation sleeving (tubing) shall be of the following types and classes, as specified:

Type I Clear (colorless).

Type III Colored black, white, or yellow.

Class 1 Cold brittle point at -90°F (-67.8°C) and flame resistance of 45 seconds.

Class 2 Cold brittle point at -67°F (-55°C) and flame resistance of 15 seconds.

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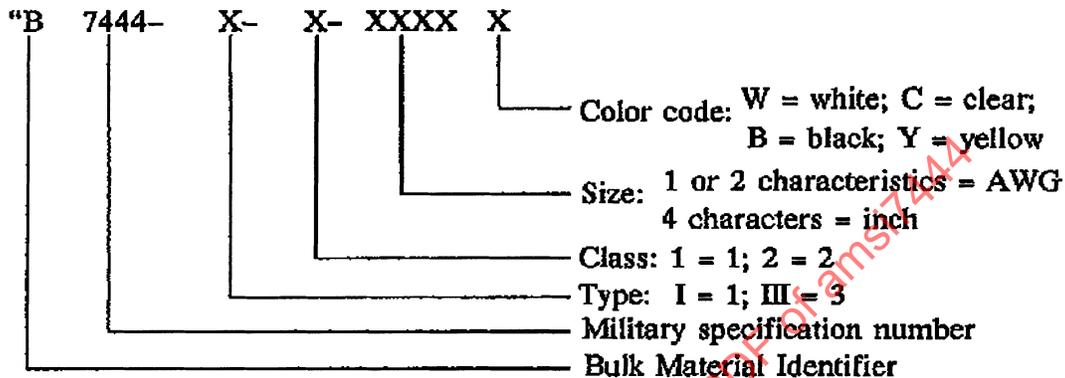
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1.3 Part numbers:

Part numbers to identify the insulation sleeving shall be formatted as shown below.



Examples: B7444-3-1-14Y; B7444-1-2-1R50C

2. APPLICABLE DOCUMENTS:

The following publications, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-P-116	Preservation, Methods of
MIL-L-10547	Liner, Case, and Sheet, Overwrap, Water Vaporproof or Waterproof, Flexible
MIL-STD-104	Limits for Electrical Insulation Color
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet
QQ-C-576	Copper Flat Products with Slit, Slit and Edge-Rolled, Sheared, Sawed or Machined Edges (Plate, Bar, Sheet and Strip)
TT-S-735	Standard Test Fluids, Hydrocarbon
PPP-B-585	Box, Wood, Wirebound
PPP-B-591	Boxes, Shipping, Fiberboard, Wood-Cleated
PPP-B-601	Boxes, Wood, Cleated-Plywood
PPP-B-621	Boxes, Wood, Nailed and Lock-Corner
PPP-B-636	Boxes, Shipping, Fiberboard
PPP-T-76	Tape, Pressure-Sensitive Adhesive, Packaging/Paper (for Carton Sealing)

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor, West Conshohoken, PA 19428-2959.

ASTM D 412 Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension

ASTM D 746 Brittleness Temperature of Plastics and Elastomers by Impact

ASTM D 792 Density and Specific Gravity (Relative Density) of Plastics by Displacement

ASTM D 876 Nonrigid Vinyl Chloride Polymer Tubing Used for Electrical Insulation

ASTM D 3767 Rubber - Measurement of Dimensions

2.3 Uniform Classification Committee Agent:

Available from the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.

Uniform Freight Classification Rules

3. REQUIREMENTS:

3.1 Preproduction:

This specification provides for preproduction inspection (see 4.3 and 6.2).

3.2 Data:

Unless otherwise specified in the contract or order, no data (other than reports accompanying preproduction samples) are required by this specification or any of the documents referenced in section 2, herein (see 6.2).

3.3 Material:

The material shall be a vinyl chloride or vinyl chloride acetate copolymer. The material shall be homogeneous, free from flaws, defects, pinholes, bubbles, seams, cracks, or inclusions.

3.4 Dimensions:

The dimensions and tolerances of the tubing shall be in accordance with table I.

TABLE 1. Inside diameters and wall thickness of tubings.

Size No. AWG	Inside diameter (inches)			Wall thickness (inches)		
	Nominal	Minimum	Maximum	Minimum	Maximum	Nominal
24	0.022	0.020	0.027	0.010	0.014	0.012
22	0.027	0.025	0.032	0.010	0.014	0.012
20	0.034	0.032	0.039	0.013	0.019	0.016
19	0.038	0.036	0.044	0.013	0.019	0.016
18	0.042	0.040	0.049	0.013	0.019	0.016
17	0.047	0.045	0.054	0.013	0.019	0.016
16	0.053	0.051	0.061	0.013	0.019	0.016
15	0.059	0.057	0.067	0.013	0.019	0.016
14	0.066	0.064	0.072	0.013	0.019	0.016
13	0.076	0.072	0.080	0.013	0.019	0.016
12	0.085	0.081	0.089	0.013	0.019	0.016
11	0.095	0.091	0.101	0.013	0.019	0.016
10	0.106	0.102	0.112	0.013	0.019	0.016
9	0.118	0.114	0.124	0.017	0.023	0.020
8	0.133	0.129	0.141	0.017	0.023	0.020
7	0.148	0.144	0.158	0.017	0.023	0.020
6	0.166	0.162	0.178	0.017	0.023	0.020
5	0.186	0.182	0.198	0.017	0.023	0.020
4	0.208	0.204	0.224	0.017	0.023	0.020
3	0.234	0.229	0.249	0.017	0.023	0.020
2	0.263	0.258	0.275	0.017	0.023	0.020
1	0.294	0.289	0.311	0.017	0.023	0.020
0	0.330	0.325	0.347	0.017	0.023	0.020
1/ R313		0.313	0.334	0.022	0.028	0.025
R375		0.375	0.399	0.022	0.028	0.025
R438		0.438	0.462	0.022	0.028	0.025
R500		0.500	0.524	0.022	0.028	0.025
R562		0.562	0.592	0.025	0.035	0.030
R625		0.625	0.655	0.025	0.035	0.030
R750		0.750	0.786	0.030	0.040	0.035
R875		0.875	0.911	0.030	0.040	0.035
1R00		1.000	1.036	0.030	0.040	0.035
1R25		1.250	1.290	0.035	0.045	0.040
1R50		1.500	1.550	0.039	0.051	0.045
1R75		1.750	1.812	0.047	0.063	0.055
2R00		2.000	2.070	0.050	0.070	0.060
2R25		2.250	2.330	0.055	0.075	0.065
2R50		2.500	2.590	0.060	0.080	0.070

1/ R used in the inch designation represents decimal point.

3.5 Length and put-up:

The tubing shall be evenly wound in a non-returnable manner (spools or rolls) in lengths not less than 100 feet for tubing under 1 inch and not less than 50 feet for tubing in sizes 1 inch and over. The tubing shall not exceed 3 pieces for 100 feet lengths and shall not exceed 2 pieces for 50 feet lengths.

3.6 Color:

3.6.1 Type I: Type I tubing shall be clear (colorless). The tubing shall not be color tinted more than the No. 2 glass of the Hellige Color Comparator when tested in accordance with 4.6.1.

3.6.2 Type III: The color of type III tubing shall conform to class 1 of MIL-STD-104 and shall be black, white, or yellow.

3.7 Tensile strength:

When tested in accordance with 4.6.2, the original tensile strength of the tubing shall be not less than 1,800 pounds per square inch. When tested in accordance with 4.6.2.1, the tensile strength of tubing aged for 168 hours at $158 \pm 2^{\circ}\text{F}$ ($70 \pm 1.1^{\circ}\text{C}$) shall be within ± 15 percent of the original.

3.8 Ultimate elongation:

When tested in accordance with 4.6.3, the original ultimate elongation of the tubing shall be not less than 200 percent. When tested in accordance with 4.6.3.1, the ultimate elongation of tubing aged for 168 hours at $158 \pm 2^{\circ}\text{F}$ ($70 \pm 1.1^{\circ}\text{C}$) shall be within ± 15 percent of the ultimate elongation of the original (unaged) specimen.

3.9 Flame resistance:

When tested in accordance with 4.6.4, the average duration of burning of the tubing shall not exceed 45 seconds for class 1, types I and III tubing and 15 seconds for class 2, types I and III tubing, and the paper indicator shall show no evidence of having been affected.

3.10 Brittle point:

When tested as specified in 4.6.5, the original tubing and tubing aged for 168 hours at $158 \pm 2^{\circ}\text{F}$ ($70 \pm 1.1^{\circ}\text{C}$) shall not fail at $-90 \pm 1.8^{\circ}\text{F}$ ($-67.8 \pm 1^{\circ}\text{C}$) for class 1, types I and III tubing and $-67 \pm 2^{\circ}\text{F}$ ($-55 \pm 1.1^{\circ}\text{C}$) for class 2, types I and III tubing.

3.11 Corrosion:

The tubing shall not accelerate corrosion of any metals with which it may come in contact (see 4.6.9).

3.12 Oil aging:

When tested in accordance with 4.6.10, tubing aged in oil for eight hours at $212 \pm 2^\circ\text{F}$ ($100 \pm 1.1^\circ\text{C}$) shall neither be tacky nor show signs of decomposition, and when flexed shall neither crack nor split.

3.13 Fungus resistance:

The tubing shall not support fungus growth and the fungicide shall not contain mercury (see 4.6.11).

3.14 Specific gravity:

The specific gravity shall be a maximum of 1.45.

3.15 Dielectric strength:

When tested in accordance with 4.6.7, the dielectric strength of the tubing shall be not less than 200 volts per mil.

3.16 Wet dielectric strength:

When tested in accordance with 4.6.8, the dielectric strength of the tubing immediately after water immersion shall be not less than 200 volts per mil and shall be within ± 20 percent of the original.

3.17 Marking:

Each spool shall be durably and legibly marked with the following information, either upon each spool or on a durable tag securely fastened to each spool:

INSULATION SLEEVING, ELECTRICAL, FLEXIBLE

Specification, MIL-I-7444

Stock No.

Part No.

Length

Contract No.

3.18 Workmanship:

Workmanship shall be such as to enable the insulation sleeving to meet all applicable requirements of the specification when inspected in accordance with section 4.

4. QUALITY ASSURANCE PROVISIONS:

4.1. Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. 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.

- 4.1.1 Responsibility for compliance: All items shall meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspections, as part of manufacturing operations, is an acceptance practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspection:

The inspection of the tubing shall be classified as follows:

- a. Preproduction inspection (4.3).
- b. Quality conformance inspection (4.4).

4.3 Preproduction inspection:

- 4.3.1 Preproduction sample: The preproductive sample shall consist of any size within the size range specified in 4.3.2 and table II.

TABLE II. Ranges of sizes for tubing.

Range	Number
24 AWG to 1/2 inch	I
9/16 inch to 1 1/2 inch	II
1 3/4 inch to 2 1/2 inch	III

4.3.2 Preproduction tests: Preproduction tests are required for the size of tubing from each of the following:

Type I, class 1, range I
 Type I, class 1, range II
 Type I, class 1, range III

Type I, class 2, range I
 Type I, class 2, range II
 Type I, class 2, range III

Preproduction tests are not required for type III, colored, if there has been previous approval of a type I, colorless, tubing of the same class and range. A type III material should be a type I tubing with a color agent added.

4.3.3 Previous approval: The preproduction testing need not be repeated for new orders, provided the materials and processes have not been changed and a certified statement to this effect is furnished to the procuring activity. The test reports shall certify that material is in accordance with 3.3.

4.4 Quality conformance inspection:

4.4.1 Sampling for quality conformance inspection:

4.4.1.1 Lot: For purposes of sampling, an inspection lot for examination and tests shall consist of all tubing of the same type, class, size, and formulation submitted for acceptance and delivery at one time.

4.4.1.2 Sampling for examination of end item: For examination of the end item, sampling shall be in accordance with MIL-STD-105. Samples selected shall be examined as specified in 4.5.1.1 and 4.5.1.2.

a. The unit of product for the examination specified in 4.5.1.1 shall be 1 linear foot and the lot size shall be expressed in units of 1 foot each. The sample size shall be in accordance with inspection level III of MIL-STD-105 and the acceptable quality level (AQL) shall be equal to 2.5 percent defective. An approximately equal number of feet shall be examined from each length (spool) of tubing selected.

b. The unit of product for the examination specified in 4.5.1.2 shall be one spool. The spools examined shall be those spools from which the lengths for the samples specified in 4.4.1.2(a) were selected. The AQL shall be equal to 1.0 percent defective.

4.4.2 Sampling for examination of preservation, packaging, packing, and marking:

4.4.2.1 Preservation and packaging: Sampling for preservation and packaging examination (see 4.5.2) shall be in accordance with the applicable portions of MIL-P-116.

4.4.2.2 Packing and marking:

Sampling for packing and marking examination (see 4.5.2) shall be in accordance with the applicable subsidiary specification specified herein or as specified by the procuring activity (see 6.2).

4.4.3 Sampling for end item tests: A minimum of five lengths of tubing at least 6 feet long shall be selected at random from each lot of tubing and subjected to the tests specified in table III. No more than one length shall be selected from any one spool and each of the specimens required for a given test shall be cut from a different length of tubing so as to be representative of the entire lot submitted for acceptance.

TABLE III. Quality conformance tests.

Property	Requirement reference	Test reference
Color (type I)	3.6.1	4.6.1
Tensile strength (original)	3.7	4.6.2
Ultimate elongation (original)	3.8	4.6.3
Flame resistance	3.9	4.6.4
Brittle point (original)	3.10	4.6.5
Specific gravity	3.14	4.6.6
Dielectric strength	3.15	4.6.7
Wet dielectric strength	3.16	4.6.8

4.4.3.1 Rejection: If the sample fails one or more of the tests specified in table III, the lot represented by the sample shall be rejected.

4.5 Examinations:

4.5.1 Examinations of the end item:

4.5.1.1 Dimensions, tolerances, and workmanship: Samples selected in accordance with 4.4.1.2 and 4.4.1.2(a) shall be examined for conformance to the applicable dimensions and tolerances specified in 3.4 and workmanship as specified in 3.18. Type III tubing shall be examined for conformance to the color requirement specified in 3.6.2. MIL-STD-104 shall be used for this examination.

4.5.1.2 Length and marking: Samples selected in accordance with 4.4.1.2 and 4.4.1.2(b) shall be examined for conformance to 3.5 and 3.17.

- 4.5.2 Examination of preservation, packaging, packing, and marking: Samples selected in accordance with 4.4.2.1 and 4.4.2.2 shall be examined for conformance to section 5.
- 4.6 Test methods:
- 4.6.1 Color (type I): The Hellige Color Comparator for varnishes shall be used; only the disk shall be used, not the viewer. The disk and a single thickness of tubing shall be placed side by side on a piece of white bond paper and compared visually under 4,500°K cool white fluorescent light. Three specimens shall be tested to determine conformance in 4.61.
- 4.6.2 Tensile strength (original): The tensile strength of three specimens of the original tubing shall be determined in accordance with ASTM D 412, except that the thickness of the specimens shall be measured in accordance with ASTM D 3767 (section 8.2, method A1), where applicable. The dumbbell-shaped specimens shall be cut with a No. VI die; if the tubing is too small for die cutting; the tubing shall be tested in full section.
- 4.6.2.1 Tensile strength after aging: The thickness of three specimens shall be measured and the specimens then aged in a convection oven for 168 hours at 158° ±2°F (70° ±1.1°C). The specimens shall be cooled at 77° ±2°F (25° ±1.1°C) for a period of 16 to 48 hours and subjected to the test specified in 4.6.2.
- 4.6.3 Ultimate elongation (original): The ultimate elongation of three specimens of the original tubing shall be determined in accordance with ASTM D 412.
- 4.6.3.1 Ultimate elongation after aging: Three specimens shall be aged and cooled as specified in 4.6.2.1 and then tested in accordance with 4.6.3.
- 4.6.4 Flame resistance:
- 4.6.4.1 Test apparatus:
- 4.6.4.1.1 Sheet-metal enclosure: A three-wall sheet-metal enclosure shall be used, measuring 12 inches wide by 14 inches long by 29 inches high. The two walls facing each other shall support two parallel horizontal steel rods. The two rods shall be one-fourth inch in diameter and shall be separated 16 to 21 inches, as required, with the lower rod closer to the back wall. The steel rods shall be so located that they define a plane which is set at an angle of 70 degrees to the horizontal.
- 4.6.4.1.2 Bare steel wire: A length of bare steel wire approximately 0.029 inch in diameter for all sizes of specimens shall be attached at one of its ends to the center of the upper rod. The other end of the wire shall pass over the center of the lower rod and shall have a 1-pound weight so attached that the wire is in a straight line across the two rods.
- 4.6.4.1.3 Tirrill burner: A Tirrill-type burner shall be used having a nominal bore of three-eighth inch and a length of approximately 4 inches above the primary outlets.

- 4.6.4.1.4 Gas supply: A supply of ordinary illuminating gas at normal pressure shall be available.
- 4.6.4.1.5 Timer: A timer measuring seconds shall be used.
- 4.6.4.1.6 Flame indicators: Strips of gummed paper shall be used as flame indicators.
- 4.6.4.2 Test specimens: For tubing having an inside diameter of seven-eighth inch or less, five test specimens 17 inches long shall be cut from the sample. For tubing having an inside diameter of more than seven-eighth inch, five test specimens 20 inches long shall be cut from the sample.
- 4.6.4.3 Preparation of specimen and apparatus for test:
- 4.6.4.3.1 Round tubing: The specimen shall be drawn onto the wire and the covered wire fastened into position. The length of the wire shall be so adjusted that the weight hangs free and maintains such tension as to support the specimen in a straight line at an angle of 70 degrees to the horizontal. One end of the specimen shall be near the lower rod and the other end shall be drawn to the upper rod and closed by clamping to prevent a draft throughout the specimen. The paper indicator shall be applied to the upper end of the specimen as follows:
- For tubing seven-eighth inch and less in inside diameter, the lower edge of the paper indicator shall be 10 inches away from the point at which the inner cone of the test flame is to be applied.
 - For tubing more than seven-eighth inch in inside diameter, the lower edge of the paper indicator shall be 15 inches away from the point at which the inner cone of the test flame is to be applied.
- The indicator shall be wrapped and pasted around the specimen.
- 4.6.4.3.2 Flat tubing: The wire shall support the specimen by one of the two small curvatures found in flat tubing. The flats of the tubing shall be directed vertically downward. The distance of 1 1/2 inches from burner to specimens (see 4.6.4.4) shall be between the tip of the stem and the surface of the narrow side of the flat specimen.
- 4.6.4.4 Application of flame (test procedure): The height of the flame with the burner in a vertical position shall be adjusted to 5 inches with an inner cone 1 1/2 inches high. The burner shall be placed on a base at an angle of 25 degrees to the horizontal. The burner, on the base, shall be so positioned that there is a distance of 1 1/2 inches between the tip of the stem and the surface of the specimen along the axis of the burner. The flame shall be applied to the surface of the specimen, not the end, for 15 seconds. The duration of burning upon removal of the flame shall be determined for compliance with 3.9.

- 4.6.5 Brittle point test: The low-temperature brittle point test shall be performed on original tubing and on tubing aged for 168 hours at $158^{\circ} \pm 2^{\circ}\text{F}$ ($70^{\circ} \pm 1.1^{\circ}\text{C}$). Size 7-AWG tubing and smaller tubing shall be tested in full section. Only motor-driven apparatus shall be used. The testing shall be in accordance with ASTM D 746, except as follows: Samples of the tubing shall be tested at $-67^{\circ} \pm 2^{\circ}\text{F}$ ($-55^{\circ} \pm 1.1^{\circ}\text{C}$) or $-90^{\circ} \pm 1.8^{\circ}\text{F}$ ($-67.8^{\circ} \pm 1^{\circ}\text{C}$), as applicable, using five specimens at a time. This procedure shall be repeated until 20 specimens have been tested or until five failures have been encountered, whichever comes first. A maximum of 4 failures out of 20 will be permitted; five failures shall constitute failure of the sample. When test specimens retain the natural curvature of the tubing, the specimens shall be struck on the convex side. The heat transfer medium shall be methyl alcohol.
- 4.6.6 Specific gravity: The specific gravity of three specimens of the tubing shall be determined in accordance with ASTM D 792.
- 4.6.7 Dielectric strength: Three specimens in the original condition shall be subjected to the dielectric strength test in accordance with ASTM D 876, except that air shall be the surrounding medium.
- 4.6.8 Wet dielectric strength: Three specimens shall be immersed for 24 hours in distilled water at $77^{\circ} \pm 2^{\circ}\text{F}$ ($25^{\circ} \pm 1.1^{\circ}\text{C}$), removed, blotted dry, and within five minutes subjected to the test specified in 4.6.7.
- 4.6.9 Corrosion: A sufficient amount of tubing to insure at least 1 square inch of contact area shall be conditioned for a minimum of 72 hours in a desiccator or similar humidity chamber maintained at 90 to 95 percent relative humidity and $77^{\circ} \pm 2^{\circ}\text{F}$ ($25^{\circ} \pm 1.1^{\circ}\text{C}$).¹ The tubing shall then be clamped between two metal plates that have been polished with either grade FF or grade FFF powdered pumice. One plate shall be copper conforming to QQ-C-576 and the other shall be aluminum alloy conforming to condition T4 of QQ-A-250/4. The plates shall be clamped sufficiently tight to flatten the tubing and insure intimate contact. The assembly shall then be placed horizontally in the same humidity chamber for 14 days. After the exposure period, the metal plates shall be washed with acetone and examined for signs of pitting or corrosion. Pitting or corrosion shall be cause for rejection of the compound and all tubing made from that compound. A slight discoloration of the metal shall not be cause for rejection.
- 4.6.10 Oil aging: Three specimens, each approximately 6 inches long, shall be immersed in petroleum base oil conforming to type VI of TT-S-735. The oil shall be maintained at $212^{\circ} \pm 2^{\circ}\text{F}$ ($100^{\circ} \pm 1.1^{\circ}\text{C}$). At the end of eight hours, the specimens shall be removed from the oil, blotted dry with a paper towel, cooled at room temperature for 30 minutes, and bent 180 degrees over a one-fourth inch diameter mandrel at a rate of approximately 60 degrees per second. The bending test shall be conducted at room temperature and the tubing shall be examined for evidence of tackiness, decomposition, and signs of cracking or splitting when bent.
- 4.6.11 Fungus resistance: Fungus resistance shall be determined in accordance with the procedure specified hereinafter.

1. A constant humidity system for which the 77°F condition is appropriate shall be selected. One such system for a 93 percent relative humidity at 77°F (25°C) uses a saturated aqueous solution of ammonium di-hydrogen phosphate, $\text{NH}_4\text{H}_2\text{PO}_4$.