

MIL-I-631D  
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 SUPERSEDING  
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**MILITARY SPECIFICATION**  
**INSULATION, ELECTRICAL,**  
**SYNTHETIC-RESIN COMPOSITION, NONRIGID**

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

**1. SCOPE**

1.1 Scope. - This specification covers only the basic characteristics required by the synthetic insulating material, as such, and the methods suited to their satisfactory determination.

1.2 Classification.

1.2.1 Types. - Electrical insulation shall be of the following types, as specified (see 6.2):

- Type A - Polyethylene.
- Type B - Cellulose acetate butyrate.
- Type C - Cellulose acetate or cellulose triacetate.
- Type D - Ethyl cellulose.
- Type E - Vinylidene chloride copolymer.
- Type F - Polyvinyl chloride and its copolymers.
- Type G - Polyethylene terephthalate.

1.2.2 Forms. - Electrical insulation shall be furnished in the following forms, as specified (see 6.2):

- Form F - Film, in rolls (types B, C, D, and G only).
- Form S - Sheet, flat or in rolls.
- Form T - Tape.
  - Subform T<sub>f</sub> - Film tape (types B, C, D and G only).
  - Subform T<sub>s</sub> - Sheet tape.
- Form U - Tubing (see 6.7)
  - Subform U<sub>a</sub> - American-wire-gage size (AWG size) (types A, E and F only).
  - Subform U<sub>b</sub> - Cable-end-sealing size (type F only). (see 6.8)

1.2.3 Grades. - Type F electrical insulation shall be furnished in the following grades, as specified (see 6.2):

- Grade a - General purpose.
- Grade b - Low temperature (form U only).
- Grade c - High temperature (form U only).

1.2.4 Classes. - Electrical insulation shall be furnished in the following classes, as specified (see 6.3):

- Class I - Fungus resistance required.
- Class II - Fungus resistance not required.

1.2.5 Categories. - Type F, form U tubing shall be furnished in the following category:

- Category 1 - Flame resistance required.

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## 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

- L-P-406 - Plastics, Organic: General Specifications, Test Methods.
- VV-1-530 - Insulating Oil, Electrical (For Transformers, Switches, and Circuit Breakers).
- PPP-B-576 - Box, Wood, Cleated, Veneer, Paper Overlaid.
- PPP-B-585 - Box, Wood, Wirebound.
- PPP-B-591 - Box, Fiberboard, Wood-Cleated.
- PPP-B-601 - Box, Wood, Cleated-Plywood.
- PPP-B-621 - Box, Wood, Nailed and Lock Corner.
- PPP-B-636 - Box, Fiberboard.
- PPP-T-60 - Tape, Pressure Sensitive Adhesive, Waterproof - For Packaging and Sealing.

#### MILITARY

- ML-S-3136 - Standard Test Fluids, Hydrocarbon and Iso-Octane.

### STANDARDS

#### MILITARY

- ML-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- ML-STD-129 - Marking for Shipment and Storage.

(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 specified, the issue in effect on date of invitation for bids shall apply.

### AMERICAN SOCIETY FOR TESTING MATERIALS STANDARDS

- D150 - Methods of Test for Power Factor and Dielectric Constant of Electrical Insulating Materials (Tentative). - 54T
- D676 - Methods of Testing Nonrigid Polyvinyl Tubing. - 54T

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

### OFFICIAL CLASSIFICATION COMMITTEE Uniform Freight Classification Rules

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

## 3. REQUIREMENTS

3.1 Qualification. - Electrical insulation furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein and has been listed on or approved for listing on the qualified products list.

3.2 Material. - The material shall be of a suitable synthetic-resin composition properly formulated with plasticizers, pigment, stabilizers, or other ingredients necessary to conform to this specification.

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**3.2.1 Changes in Material.** - If the manufacturer desires to change his process or the composition of his material, after qualification approval has been granted (see 5.3) he shall submit to the qualifying agency (Bureau of Ships) a statement to that effect, describing the proposed change, together with evidence to substantiate his claim that such change is feasible. Similar notification and substantiating evidence shall be submitted at any later time if a change again becomes necessary or desirable. At the discretion of the qualifying agency, test specimens may be required to prove the suitability of the proposed changes.

**3.2.2 Uniformity.** - All material in a lot of the same type and product of any one manufacturer shall be uniform in texture, color, cross section, finish, and in the properties specified in table I, II, or III, as applicable.

**3.2.3 Surface defects.** - Materials shall be free from blisters, bubbles, wrinkles, and cracks, and shall be reasonably free from other small defects such as scratches and dents.

**3.2.4 Colors.** - Materials shall be furnished uncolored (unpigmented) unless otherwise specified (see 5.2).

### **3.3 Dimensions and tolerances.** -

#### **3.3.1 Film and film tape (form F and subform T<sub>f</sub>).** -

**3.3.1.1** Film is defined as material in thicknesses of 0.002 inch or less, in widths greater than 3 inches. Material 3 inches or less in width, slit from film, is defined as film tape (subform T<sub>f</sub>).

**3.3.1.2 Thicknesses.** - Unless otherwise specified in the contract or order, the standard thicknesses of form F material, and of subform T<sub>f</sub> material cut from film, shall be as shown in table IV, as specified (see 6.2).

#### **3.3.2 Sheet and sheet tape (form S and subform T<sub>s</sub>).** -

**3.3.2.1** Sheet is defined as material in thicknesses greater than 0.002 inch and in widths greater than 3 inches. Material 3 inches or less in width, slit from sheet, is defined as sheet tape (subform T<sub>s</sub>). Thin sheets shall be supplied in rolls, if specified. (See 6.2)

Table 1. — Property values of synthetic-resin electrical insulation — forms F and T (0.002 inch and less in thickness).

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal thickness	Value required for each type of material				
					B	C	D	G	G
Dielectric strength	4.6.2	C-96/23/0	Volts per mil (min.)	0.001	2,700	2,700	3,500	3,500	3,500
		C-96/23/96	Percent of dry value obtained on test (min.)	0.015	2,350	2,350	3,000	3,000	3,000
Dissipation factor (form F only) at 1 kilocycle	4.6.3	C-96/23/0	Maximum	0.02	0.035	0.035	0.015	0.007	
		C-96/23/96	Maximum	0.02	0.035	0.035	0.015	0.007	
Dielectric constant (form F only) at 1 megacycle	4.6.3	C-96/23/0	Maximum	0.045	0.05	0.025	0.025	0.008	
		C-96/23/96	Maximum	0.055	0.07	0.045	0.045	0.030	
Volume resistivity (form F only)	4.6.4.1	C-96/23/0	Ohm-centi-meters (min.)	1013	1013	1014	1015	1015	
		C-96/23/96	Ohm-centi-meters (min.)	1012	1010	1012	1015	1015	
Tensile strength	4.6.5.1	C-96/23/50	P. e. l. (min.)	5,000	6,000	3,500	17,000	17,000	
		C-96/23/50	Percent (min.)	25	10	25	50	50	
Elongation	4.6.5.1	C-96/23/50	Percent (max.)	100	50	100	-----	-----	
		E-400/130	Percent change (max.)	-----	-----	-----	35	35	
Softening temperature (penetration)	4.6.7	C-96/23/50	Degree centi-grade (min.)	120	160	110	200	200	
		E-2/100	Percent (max.)	3.0	3.0	2.0	-----	-----	
Lengthwise shrinkage	4.6.8	E-2/100	Percent (max.)	-----	-----	-----	-----	-----	
		E-2/150	Percent (max.)	-----	-----	-----	5.0	5.0	

1 For thickness not shown, the dielectric strength shall be that given for the nearest thickness shown.

Table II. - Property values of synthetic-resin electrical insulation - forms S and T (greater than 0.002 inch in thickness).

Property to be tested	Test reference	Conditioning procedure (see 4.4)	Unit of value	Nominal thickness	Value required for each type of material							
					A	B	C	D	E	F Grades	G	
Dielectric strength -----	4.6.2	C-96/23/0	Volts per mil (minimum)	{ inch 0.003 .005 .0075 .008 .010 .012 .016 .020 .025 .030 .040 .050 .060 }	3,100	1,900	1,900	2,600	1,200	-----	-----	2,450
					2,400	1,550	1,550	2,150	1,070	-----	-----	2,000
					-----	-----	-----	-----	-----	-----	-----	-----
					-----	1,300	1,250	1,800	960	-----	-----	-----
					-----	1,200	1,150	1,550	920	-----	-----	1,600
					-----	-----	-----	-----	950	-----	-----	-----
					-----	1,000	950	1,200	940	-----	-----	-----
					-----	1,100	840	1,050	790	-----	-----	-----
					-----	820	760	920	740	-----	-----	-----
					-----	870	700	830	700	-----	-----	-----
-----	740	640	700	600	-----	-----	-----					
-----	680	550	610	530	-----	-----	-----					
-----	600	490	490	450	-----	-----	-----					
Dielectric strength -----		C-96/23/96	Percent of dry value obtained on test (min.)	All thicknesses	75	85	75	55	90	90	-----	-----
Dielectric strength -----		C-96/23/96	Percent of dry value obtained on test (min.)	inch .003 .005 .0075	-----	-----	-----	-----	-----	-----	-----	85 90 90
Dissipation factor (form S only) At 1 kilocycle At 1 megacycle	4.6.3	C-96/23/0 C-96/23/96 C-96/23/0 C-96/23/96	Maximum Maximum	-----	Natural colors Other colors	0.0006	0.02	0.035	0.015	0.08	0.14	0.006
						.0008	.03	.070	.03	.08	.16	.0065
						.0006	.045	.05	.028	-----	-----	.020
						.0008	.055	.07	.045	-----	-----	.025
Dielectric constant (form S only) At 1 kilocycle At 1 megacycle	4.6.3	C-96/23/0 C-96/23/96 C-96/23/0 C-96/23/96	Maximum Maximum	-----	Natural colors Other colors	2.5	4.0	4.5	4.0	5.0	7.0	3.5
						2.7	5.0	6.7	5.0	6.0	8.0	3.7
						2.5	4.0	4.3	4.0	-----	-----	3.3
						2.7	5.0	7.0	5.0	-----	-----	3.5

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Table II. — Property values of synthetic-resin electrical insulation — forms S and T (greater than 0.002 inch in thickness) (cont'd.)

Property to be tested	Test reference	Conditioning procedure (see 4.4)	Unit of value	Nominal thickness	Value required for each type of material						
					A	B	C	D	E	F	G
Volume resistivity (form S only) -----	4.6.4.1	C-96/23/0 C-96/23/96	Ohm-centimeters (min.)	-----	1017	1013	1013	1014	1013	1011	1015
					1016	1012	1010	1012	1010	1010	1015
Tensile strength ----	4.6.5.1	C-96/23/50	P. s. i. (min.)	-----	1,400	5,000	6,000	3,500	3,500	1,000	17,000
					350	25	10	25	15	200	70
Elongation ---	4.6.5.1	C-96/23/50 E-400/100	Percent (min.) Percent (max.) Percent change (max.)	-----	-----	100	50	100	100	450	-----
					-----	-----	-----	-----	-----	15	-----
Elongation ---	4.6.5.2	E-400/130 C-96/23/50	Percent change (max.) Percent (min.)	-----	-----	-----	-----	-----	-----	-----	25
					-----	-----	-----	-----	-----	60	-----
Softening temperature (penetration)	4.6.7	C-96/23/50	Degrees centigrade (min.)	-----	65	120	160	110	120	75	200
					-----	-----	-----	-----	-----	-----	-----
Lengthwise shrinkage --	4.6.8	E-2/100 E-2/150	Percent (max.) Percent (max.)	-----	2.0	3.0	3.0	2.0	3.0	10.0	-----
					-----	-----	-----	-----	-----	-----	3.0

1 For thickness not shown, the dielectric strength shall be that given for the nearest thickness shown.

Table III. - Property values of synthetic-resin electrical insulation form V.

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Values required for each type of material					
					A	E	F Grade a	F Grade b	F Grade c	F
Dielectric strength	4.6.2	C-96/23/0	Volts per mil (min.)	Inches wall thickness	1.250	0.820	400	750	600	600
					1.100	790	700	650	700	700
Dielectric strength	-----	C-96/23/96	Percent of dry value obtained (min.)	All thicknesses	85	90	90	85	85	85
					-----	-----	-----	-----	-----	-----
Dissipation factor At kilocycle	4.6.3	C-96/23/0 C-96/23/96	Maximum	-----	Natural colors	0.0004	0.0014	0.14	0.14	0.14
					Other colors	{ 0.0004 } { 0.0010 } { 0.0025 }	{ 0.0014 } { 0.0016 }	{ 0.14 } { 0.16 }	{ 0.14 } { 0.16 }	{ 0.14 } { 0.16 }
At megacycle	-----	C-96/23/96	Maximum	-----	Natural colors	{ 0.0004 } { 0.0006 }	{ 0.0014 } { 0.0025 }	{ 0.14 } { 0.16 }	{ 0.14 } { 0.16 }	{ 0.14 } { 0.16 }
					Other colors	{ 0.0006 } { 0.0025 }	{ 0.0025 } { 0.0040 }	{ 0.16 } { 0.25 }	{ 0.16 } { 0.25 }	{ 0.16 } { 0.25 }
Dielectric constant At kilocycle	4.6.3	C-96/23/0 C-96/23/96	Maximum	-----	Natural colors	{ 2.5 } { 2.7 }	{ 7.0 } { 8.0 }	{ 7.0 } { 8.0 }	{ 7.0 } { 8.0 }	{ 7.0 } { 8.0 }
					Other colors	{ 2.7 } { 2.9 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }
At megacycle	-----	C-96/23/96	Maximum	-----	Natural colors	{ 2.7 } { 2.9 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }	{ 8.0 } { 9.0 }
					Other colors	{ 2.9 } { 3.1 }	{ 9.0 } { 10.0 }	{ 9.0 } { 10.0 }	{ 9.0 } { 10.0 }	{ 9.0 } { 10.0 }
Volume resistivity	4.6.4.2	D1-24/23	Ohm-centimeters (min.)	-----	-----	1010	1010	1010	1010	
Tensile strength	4.6.5.1	C-96/23/50 C-96/23/96	P. s. i. (min.)	-----	1,400	3,500	3,800	1,450	1,400	1,400
					350	100	200	200	200	200
Elongation	4.6.5.1	E-400/100 E-400/130	Percent change (max.)	-----	-----	-----	-----	-----	-----	-----
					-----	-----	-----	-----	-----	-----

1 For thickness not shown, the dielectric strength shall be that given for the nearest thickness shown.

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Table III. - Property values of synthetic-resin electrical insulation form U (cont'd.)

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Value required for each type of material					
					A	E	F Grade a	F Grade b	F Grade c	
Bareing strength (subform U <sub>b</sub> only) increasing pressure -----	4.6.6	C-96/23/50	P. s. i. (min.)	inches inside diameter	0.162	---	96	96	96	96
					0.190	---	80	80	80	80
					0.250	---	59	59	59	59
					0.280	---	53	53	53	53
					0.320	---	46	46	46	46
					0.360	---	41	41	41	41
					0.400	---	36	36	36	36
					0.430	---	31	31	31	31
					0.450	---	28	28	28	28
					0.520	---	24	24	24	24
					0.570	---	21	21	21	21
					0.630	---	18	18	18	18
					0.680	---	16	16	16	16
					0.760	---	14	14	14	14
					0.820	---	13	13	13	13
					0.850	---	12	12	12	12
					0.890	---	11	11	11	11
					0.960	---	10	10	10	10
					1.030	---	9	9	9	9
					1.100	---	8	8	8	8
1.165	---	7	7	7	7					
1.225	---	6	6	6	6					
1.285	---	5	5	5	5					
1.365	---	4	4	4	4					
1.470	---	3	3	3	3					
1.585	---	2	2	2	2					
Bareing strength (subform U <sub>b</sub> only) Continuous pressure -----	4.6.6	C-96/23/50	P. s. i. (min.)	-----	-----	2/	2/	2/	2/	

2/One-half of above value.

Table III. - Property values of synthetic-resin electrical insulation form. II (cont'd.)

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Value required for each type of material					
					A	E	F Grade a	F Grade b	F Grade c	
Softening temperature (penetration) -	4.6.7	C-96/23/50	Degrees centigrade (min.)	inches wall thickness	65	120	75	70	70	70
					.016	120	75	70	70	70
					.020	120	75	70	70	75
					.025	120	75	70	70	75
					.030	120	75	70	70	75
					.035	120	75	70	70	75
					.040	120	75	70	70	85
					.045	120	75	70	70	85
					.050	120	75	70	70	85
					.055	120	75	70	70	85
.060	120	75	70	70	85					
Lengthwise shrinkage ----	4.6.8	E-2/100	Percent (max.)	5.0	5.0	10.0	10.0	10.0	10.0	
		E-2/130	Percent (max.)	5.0	5.0	10.0	10.0	10.0	10.0	
Cold brittleness	4.6.12	-----	Degrees centigrade (max.)	-60	-24	-30	-46	-10	-10	
		-----	Degrees centigrade (max.)	-60	-24	-30	-46	-10	-10	

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Table IV. - Standard thicknesses of film and film tape (form F and subform T<sub>f</sub>).

Nominal thickness	Tolerance (±)	
	Type G	Other types
Inch	Inch	Inch
0.005	0.0001	-----
.0010	.0002	0.0001
.0015	-----	.0002
.002	.0004	.0002
.003	.0004	-----
.005	.0005	-----
.0075	.0005	-----
.01	.0005	-----

3.3.2.2 Thicknesses. - Unless otherwise specified in the contract or order, the nominal thicknesses and tolerances on thicknesses of form S material, and of subform T<sub>g</sub> material cut from sheets, shall be as shown in table V, as specified (see 6.2):

Table V. - Nominal thicknesses and tolerances of sheet and sheet tape (form S and subform T<sub>g</sub>).

Nominal thickness	Tolerance (±)		
	Type F grade a	Type G	Other types
Inch	Inch	Inch	Inch
0.003	-----	0.0006	0.0003
.005	-----	.001	.0005
.0075	-----	.0015	-----
.008	0.0008	-----	.0008
.010	-----	-----	.0010
.012	.0012	-----	-----
.016	.0016	-----	.0016
.020	.0020	-----	.0020
.025	.0025	-----	.0025
.030	.0030	-----	.0030
.040	.0040	-----	.0040
.050	.0050	-----	.0050
.060	.0060	-----	.0060

At least 90 percent of the area of the sheet shall be within this variation, and at no point shall the thickness as measured vary from the nominal by a value greater than 12.5 percent.

3.3.3 Tape. - Tape shall be furnished in any specified thickness, in rolls of 3 inches wide or less, wound over a suitable cylindrical core for subsequent application by hand or machine taping. (See 6.2) The thicknesses and thickness tolerances for extruded tapes shall be as specified in 3.3.1.2, 3.3.2.2, as applicable and as specified (see 6.3).

3.3.3.1 Tape shall be uniform, even, and smooth in appearance, with a surface entirely free from holes. The edges shall be straight, true, and unbroken. It shall be tightly wound in rolls, with a suitable separator between layers, when necessary, to prevent the material from adhering to itself when unwound from the roll. When unwound from the roll, the tape shall remain reasonably flat with no tendency to curl

transversely. The tape, when correctly applied, shall adhere snugly without wrinkling, curling, or buckling.

**3.3.3.2 For application by machine.** - When the material is required for machine-taping, the width, tolerance on the width, and length of material on the roll, the overall diameter of the roll, and the mandrel diameter of the cylindrical core shall be as specified (see 6.2).

**3.3.3.3 For application by hand.** - When the material is required for hand-taping, it shall, unless otherwise specified in the contract or order, be put up in rolls approximately 4-1/2 inches in diameter, wound over a suitable 1 to 1-1/2 inch core convenient for hand application. Unless otherwise specified in the contract or order, tape for hand application shall be furnished in the standard widths shown in table VI, as specified (see 6.2).

Table VI - Standard widths of tape for application by hand (form T).

Width	Tolerance (plus or minus)		
	Type G		Other types
	0.001 - 0.002 inch nominal thickness	0.003 - 0.0075 inch nominal thickness	All thickness
Inches	inch	inch	inch
0.50	0.03	0.03	0.02
.75	.03	.03	.02
1.00	.03	.03	.02
1.25	.03	.03	.04
1.50	.03	.03	.04
2.00	.03	.03	.04
2.50	.03	.06	.04
3.00	.03	.06	.04

**3.3.4 Tubing (form U).** -

**3.3.4.1** Unless otherwise specified in the contract or order, tubing shall be furnished on reels in lengths specified in table VII. (See 6.2.) Tubing furnished on reels shall be wound on the reel in such a manner that the tubing will not be flattened or kinked to an extent that printing of circuit identification by machine, if desired, cannot be accomplished. Minimum lengths specified shall not be exceeded by more than 10 percent.

Table VII - Tubing lengths.

Nominal inside diameter	Minimum length
inch	Feet
0.034 - 0.059	1,000
0.066 - 0.166	500
0.186 - 0.330	300
0.360 and over	100

**3.3.4.2 Inside diameters and wall thicknesses.** - Unless otherwise specified in the contract or order, tubing shall be furnished in the standard inside diameters and wall thicknesses shown in tables VIII or IX as specified (see 6.2).

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Table VIII. — Inside diameters and wall thicknesses of tubing AWG sizes (subform U<sub>2</sub>).

AWG Size No.	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	.027	.025	.032	.010	.014	.012
20	.034	.032	.039	.013	.019	.016
19	.038	.036	.044	.013	.019	.016
18	.042	.040	.049	.013	.019	.016
17	.047	.045	.054	.013	.019	.016
16	.053	.051	.061	.013	.019	.016
15	.059	.057	.067	.013	.019	.016
14	.066	.064	.072	.013	.019	.016
13	.076	.072	.080	.013	.019	.016
12	.085	.081	.089	.013	.019	.016
11	.095	.091	.101	.013	.019	.016
10	.106	.102	.112	.013	.019	.016
9	.118	.114	.124	.017	.023	.020
8	.133	.129	.141	.017	.023	.020
7	.148	.144	.158	.017	.023	.020
6	.166	.162	.178	.017	.023	.020
5	.186	.182	.198	.017	.023	.020
4	.208	.204	.224	.017	.023	.020
3	.234	.229	.249	.017	.023	.020
2	.263	.258	.278	.017	.023	.020
1	.294	.289	.311	.017	.023	.020
0	.330	.325	.347	.017	.023	.020
5/16 in.	-----	.313	.334	.022	.028	.025
3/8 in.	-----	.375	.399	.022	.028	.025
7/16 in.	-----	.438	.462	.022	.028	.025
1/2 in.	-----	.500	.524	.022	.028	.025
5/8 in.	-----	.625	.655	.025	.035	.030
3/4 in.	-----	.750	.786	.030	.040	.035
7/8 in.	-----	.875	.911	.030	.040	.035
1 in.	-----	1.000	1.036	.030	.040	.035
1-1/4 in.	-----	1.250	1.290	.035	.045	.040
1-1/2 in.	-----	1.500	1.550	.039	.051	.045
1-3/4 in.	-----	1.750	1.812	.047	.063	.055
2 in.	-----	2.000	2.070	.050	.070	.060

Table IX. — Inside diameters and wall thicknesses of tubing, cable-end-sealing sizes (subform U<sub>2</sub>) — (see 6.8) Type F only.

Nominal	Inside diameter (inches)		Wall thickness (inches)		
	Minimum	Maximum	Minimum	Maximum	Nominal
0.162	0.155	0.170	0.018	0.023	0.020
.190	.185	.200	.018	.023	.020
.250	.245	.260	.018	.023	.020
.280	.275	.290	.018	.023	.020
.320	.315	.330	.018	.023	.020
.360	.355	.375	.018	.023	.020
.400	.395	.420	.028	.033	.030
.430	.425	.450	.028	.033	.030
.450	.445	.470	.028	.033	.030
.520	.515	.540	.028	.033	.030
.570	.565	.590	.037	.043	.040

Table IX. -- Inside diameters and wall thicknesses of tubing, cable-end-sealing sizes (subform U<sub>D</sub>) - (see 4. 8) Type F only (cont'd.).

Inside diameter (inches)			Wall thickness (inches)		
Nominal	Minimum	Maximum	Minimum	Maximum	Nominal
. 630	. 625	. 650	. 037	. 043	. 040
. 680	. 675	. 700	. 037	. 043	. 040
. 760	. 750	. 785	. 037	. 043	. 040
. 820	. 810	. 845	. 046	. 054	. 050
. 850	. 840	. 890	. 046	. 054	. 050
. 890	. 880	. 925	. 046	. 054	. 050
. 960	. 950	1. 000	. 046	. 054	. 050
1. 030	1. 020	1. 070	. 046	. 054	. 050
1. 100	1. 090	1. 150	. 046	. 054	. 050
1. 165	1. 150	1. 200	. 055	. 065	. 060
1. 225	1. 205	1. 255	. 055	. 065	. 060
1. 285	1. 260	1. 310	. 055	. 065	. 060
1. 365	1. 345	1. 400	. 055	. 065	. 060
1. 470	1. 455	1. 510	. 055	. 065	. 060
1. 585	1. 565	1. 615	. 055	. 065	. 060

3. 4 Quantitative requirements (property values). - When specimens are subjected to the tests specified in tables I, II, or III, as applicable, the values obtained from any set of specimens cut from one sheet, roll, or reel for any specific property after any one conditioning procedure specified in the table shall be averaged, and this average value shall be not less than the minimum nor more than the maximum value (as applicable) specified in table I, II, or III, as applicable.

3. 5 Qualitative requirements. -

3. 5. 1 Effect of heat on materials under tension (type F, form S and subform T<sub>R</sub> only). - The material shall not crack or split in layers when tested as specified in 4. 6. 9.

3. 5. 2 Flexibility after aging. -

3. 5. 2. 1 Oven aging. - None of the samples of material shall exhibit cracks due to hardening when tested as specified in 4. 6. 10. 2. In the testing of form U material, cracking at the creased edges of the bend shall be disregarded.

3. 5. 2. 2 Ultra-violet-light aging (type F, form U, grade b only). - Type F, grade b material shall not exhibit cracks due to hardening when tested as specified in 4. 6. 10. 3. In the testing of form U material, cracking at the creased edges of the bend shall be disregarded.

3. 5. 3 Cold bend (forms F, S and T only). - The material shall not crack or break when tested as specified in 4. 6. 11.

3. 5. 4 Flame resistance (type F, form U only). - The average duration of burning shall not exceed 15 seconds, and the paper indicator shall show no evidence of being affected when tested as specified in 4. 6. 13.

3. 5. 5 Oil resistance-flexibility (not applicable to types A and D). -

3. 5. 5. 1 Forms F, S, and T. - The material shall not increase in dimension (width or thickness) by more than 15 percent when tested as specified in 4. 6. 14. It shall not break or crack when creased on itself.

3. 5. 5. 2 Form U. - At the completion of the test specified in 4. 6. 14, oil shall not have penetrated into the tubing; and the tubing shall not have developed cracks, or increased in diameter at any point by more than 10 percent.

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3.5.6 Corrosive effect. - Copper shall not be corroded or otherwise adversely affected by contact with the material. The resistance of the copper wire shall not increase by more than 2 percent. (See 4.5.15.)

3.5.7 Fungus resistance (class I). - The material shall be tested for fungus resistance as specified in 4.6.16. The material shall not support fungus growth. The material shall be considered fungus resistant if at least 2 of 3 specimens are rated 0 to 1.

3.6 Chemical analysis. - The composition of material as determined by chemical analysis on material offered under a contract or order shall not differ significantly from the composition of the samples submitted for qualification approval. (See 4.5.17.)

3.7 Storage stability (type F, form U only). - At the end of the 12 months storage specified in 4.5.13 there shall be no evidence of spewing (oily or sticky exudation) on the inner and outer surfaces of the tubing. At the end of the 12 months storage type F, form U, class I material shall conform to the fungus resistance requirements of 3.5.7.

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

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified hereinafter. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to insure supplies and services conform to prescribed requirements.

4.2 Classification of inspection. - The methods of sampling, examination, and tests shall be classified as follows:

- (a) Qualification tests (see 4.3).
- (b) Acceptance inspection (see 4.4).

4.3 Qualification tests.<sup>1/</sup> Qualification tests shall be conducted at a laboratory satisfactory to the Bureau of Ships.

4.3.1 Samples. - Separate samples for each type, form, and subform of material for which approval is requested shall be furnished in sizes and quantities shown in table X (see 4.3.2.2). (Because of the large range of sizes in forms T and U, complete qualification approval for these forms is not necessarily required. As an alternative, at the option of the manufacturer, qualification approval will be required on the individual subforms of forms T and U for which it is desired.) (See 1.2, tables VIII and IX, and 4.3.2.2.)

#### 4.3.2 Tests. -

4.3.2.1 All samples shall be subjected to the tests shown in table XI except as specified in 4.3.2.2.

4.3.2.2 Tape cut from film or sheet. - Qualification testing will not be required on tape which is formed by slitting film or sheet when qualification for such film or sheet has already been obtained. Complete qualification testing will be required on tape formed directly by extrusion or on tape slit from film or sheet for which qualification approval has not been obtained (see 4.3.1).

4.3.3 Failures. - Failure of any of the specimens in any one of the tests for each type, form, and subform submitted may be cause for refusal to grant qualification approval for that particular type, form or subform.

4.4 Acceptance inspection. - Acceptance inspection shall be conducted on samples selected in accordance with 4.4.1.2 and 4.4.1.3.

<sup>1/</sup> Application for qualification tests should be made in accordance with "Provisions Governing Qualification".

Table X. - Sizes and quantities of material for qualification tests.

Form	Subform	Size number	Nominal inside diameter	Nominal thickness or wall thickness			Nominal width	Amount
				Inch	Inch	Inch		
F			inches	0.001 .002			4 to 36 4 to 36	10 sq. yds 10 sq. yds
S				Type F 0.008 .020	Type G 0.005 0.0075	Other types 0.010 .020	4 to 36 4 to 36	10 sq. yds 10 sq. yds
T <sup>1</sup>	T <sub>F</sub> <sup>1/</sup>			0.001 .002			1 1	1,000 feet 1,000 feet
	T <sub>S</sub> <sup>1/</sup>			Type F 0.008 .020	Type G 0.005 0.0075	Other types 0.010 .020	1 1	1,000 feet 1,000 feet
U	U <sub>A</sub>	18 12 6		0.016 .016 .020				200 feet 200 feet 200 feet
	U <sub>B</sub> / Type F only		1.030	0.050				100 feet

<sup>1/</sup>One square yard of sheet or film material in each thickness will also be required when tape is obtained by slitting (see 4.3.2.2). The material shall be furnished in any convenient width from 4 to 36 inches. The material shall be subjected to the dissipation factor, dielectric constant, and volume resistivity tests specified in table XI.

Table XI. - Qualification tests.

Test	Requirement reference	Test reference	Minimum number of tests for each condition (see 4.5 to 4.5.2, inclusive)
General examination	3.2 to 3.3.4.2, inclusive, and 3.8	4.6.1	10
Electrical properties:			
Dielectric strength	3.4	4.6.2	10
Dissipation factor (forms F, S and U only) <sup>1/</sup>	3.4	4.6.3	3
Dielectric constant (forms F, S and U only) <sup>1/</sup>	3.4	4.6.3	3
Volume resistivity:			
Forms F and S only <sup>1/</sup>	3.4	4.6.4.1	3
Type F, form U only	3.4	4.6.4.2	3
Mechanical properties:			
Tensile strength	3.4	4.6.5.1	10

See footnote at end of table.

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Table XI. - Qualification tests (cont'd.).

Test	Requirement reference	Test reference	Minimum number of tests for each condition (see 4.5 to 4.5.3, inclusive)
<b>Mechanical properties:--(continued)</b>			
Elongation	3.4	4.6.5.1	10
Percent return (type F, form S and subform T <sub>3</sub> )	3.4	4.6.5.2	3
Bursting strength (type F, subform U <sub>3</sub> only):			
Increasing pressure	3.4	4.6.6	3
Continuous pressure	3.4	4.6.6	3
<b>Thermal properties:</b>			
Softening temperature (penetration)	3.4	4.6.7	5
Lengthwise shrinkage	3.4	4.6.8	3
Effect of heat on material under tension (type F, form S and subform T <sub>3</sub> only)	3.5.1	4.6.9	2
<b>Flexibility:</b>			
After oven aging	3.5.2.1	4.6.10.2	3
After ultra-violet-light aging (type F, form U, grade b only) <sup>1/</sup>	3.5.2.2	4.6.10.3	4
Cold bend (forms F, S and T only) <sup>1/</sup>	3.5.3	4.6.11	2
Cold brittleness (form U only)	3.4	4.6.12	As specified in 4.6.12.3
Flame resistance (type F, form U only)	3.5.4	4.6.13	5
<b>Miscellaneous:</b>			
Oil resistance-flexibility (not applicable to types A and D)	3.5.5	4.6.14	3
Corrosive effect	3.5.6	4.6.15	2
Fungus resistance (class I only)	3.5.7	4.6.16	3
Chemical analysis	3.6	4.6.17	1
Storage stability (type F, form U only). (See 4.3.3)	3.7	4.6.18	3

<sup>1/</sup> These tests shall also be conducted on specimens cut from the one square yard sample of film or sheet material in each of the thicknesses.

#### 4.4.1 Sampling. -

4.4.1.1 Lot. - A lot shall consist of all material of the same type, form, grade and class and thickness (forms F, S, and T) or inside and outside diameters (form U), manufactured in one production run and offered for delivery at the same time.

4.4.1.2 Sampling for examination. - A random sample of rolls, sheets, or reels of insulation shall be selected in accordance with table XII from each lot of material for examination of visual and dimensional characteristics with lot acceptance based on the sampling inspection requirements in accordance with Standard MIL-STD-105.

4.4.1.3 Sampling for acceptance tests. - Sample pieces, each large enough for all tests of table XIII shall be selected from one-fifth of the sample rolls, sheets, or reels of the second column of table XII. The minimum quantity taken from each roll, sheet, or reel shall be as follows:

Forms F and S . . . . .	9 square feet.
Form T . . . . .	90 linear feet.
Form U . . . . .	35 linear feet.

If any specimen fails in any test, the lot represented shall be rejected.

Table XII. - Sampling for examination AQL  
(approx.) = 2.5 percent defective.

Number of rolls, sheets or reels in the lot	Number of rolls, sheets or reels to be sampled	Acceptance number (defectives)	Rejection number (defectives)
15 and under	5	0	1
16 to 40	7	0	1
41 to 85	10	0	1
86 to 110	15	1	2
111 to 180	25	1	2
181 to 300	35	2	3
301 to 500	50	3	4
501 and over	75	4	5

Table XIII. - Acceptance tests.

Test	Requirement reference	Test reference	Conditioning prior to test (see 4.5)	Minimum number of tests per specimen
<b>Group 1 - all specimens</b>				
Dielectric strength	3.4	4.6.2	C-96/23/0	10
Tensile strength and elongation	3.4	4.6.5.1	C-96/23/96	10
Bursting strength (type F, subform U <sub>b</sub> only), continuous pressure	3.4	4.6.6	C-96/23/50	2
Lengthwise shrinkage	3.4	4.6.8	C-96/23/50	1
			As specified in table I, II, or III,	1
<b>Group 2 - not more than two specimens</b>				
Dissipation factor and dielectric constant (forms F, S, and U) at 1 kilocycle only <sup>1/</sup>	3.4	4.6.3	C-96/23/96	3
Volume resistivity (forms F and S) <sup>1/</sup>	3.4	4.6.4	C-96/23/96	3
Softening temperature (penetration)	3.4	4.6.7	C-96/23/50	3
Flexibility after oven aging	3.5.2.1	4.6.10.2	(see 4.6.10.2)	2
Cold bend (forms F, S, and T only)	3.5.3	4.6.11	-----	2
Cold brittleness (form U only)	3.4	4.6.12	-----	As specified in 4.6.12.3
Chemical analysis	3.6	4.6.17	-----	2/

<sup>1/</sup> Not required on types E and F.

<sup>2/</sup> One composite sample.

4.4.2 General examination. - The rolls, sheets, and reels shall be subjected to a thorough examination to make certain that the material and workmanship conform to 3.2.2 to 3.2.4, inclusive, and 3.8, and that the dimensions are as specified in 3.3 to 3.3.4.2. If the number of defective rolls, sheets, or reels, exceeds the acceptance number for the appropriate sampling plan in table XII, the lot shall be rejected.

4.4.3 Acceptance tests. - Tests shall consist of those specified in table XIII; all pieces selected in accordance with 4.4.1.3 shall be subjected to the group 1 tests, and not more than two samples selected in

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accordance with 4.4.1.3 shall be subjected to the group 2 tests. If one or more of the pieces fail one or more of the tests, the entire lot shall be rejected.

**4.5 Conditioning.** - Materials shall be conditioned before being tested, as specified in table I, II, or III, as applicable.

**4.5.1 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.

**4.5.2 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.)

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

**4.5.3 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 in table I, II, or III, as applicable.

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 D<sub>i</sub>** - The specimens shall be immersed in 1 percent salt water for the time and at the time temperature specified.

Example:

- D<sub>i</sub>-24/23 - 24 hours, 23°C., in 1 percent salt water.

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

Examples:

- E-400/100 - 400 hours, 100°C.
- E-2/100 - 2 hours, 100°C.
- E-400/130 - 400 hours, 130°C.

**4.6 Methods of tests.** - The methods and procedures shall be as specified in 4.6.1 to 4.6.18, inclusive. Unless otherwise specified herein, all tests shall be conducted under room conditions (23°C., 50 percent relative humidity). In the case of materials believed to be oriented, mechanical tests shall be conducted on samples cut both lengthwise and crosswise, for the properties affected by the orientation.

**4.6.1 General examination.** -

**4.6.1.1** The insulation shall be examined to verify that the materials, dimensions, and workmanship are in strict conformance with this specification. (See 3.2 to 3.3.4.2, inclusive and 3.8.)

**4.6.1.2 Methods for measurement of dimensions.** -

**4.6.1.2.1 Thickness (forms F, S, and T).** - The thickness shall be determined by the use of a dial-type micrometer. The lower or fixed anvil shall consist of a flat steel plate 2 inches in diameter; the upper or movable member shall consist of a foot or button, having a flat steel face measuring 1/4 inch in diameter, and shall be arranged so as to move with its face parallel to the face of the anvil at all times. The movable member shall be of such weight, and shall be attached to the operating rod of the micrometer in

such a manner, that 9 ounces dead weight shall be applied to all thicknesses of samples being measured. The thickness shall be determined as the average of at least 10 readings taken at representative points on the material. If the thickness so determined falls outside the specified tolerances, 10 additional readings shall be taken from another section of the material and averaged with the previous readings. The maximum, minimum, and average values shall be recorded.

**4.6.1.2.2 Width (form T).** - The width shall be determined by the use of a standard steel scale graduated to read within 0.01 inch. The tape shall be flat on a smooth surface at the time of measurement. At least 10 measurements shall be made at representative points on the material, and the maximum, minimum, and average values shall be recorded.

**4.6.1.2.3 Diameter and wall thickness (form U).** - The inside diameter, the outside diameter, and wall thickness of the tubing shall be determined in accordance with the method specified in ASTM D876. 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.

#### **4.6.2 Dielectric strength.**

**4.6.2.1 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.

**4.6.2.2 Voltage control.** - The high-tension voltage taken from the secondary of the testing transformer shall be capable of being raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation with an induction regulator, or with a variable ratio autotransformer. Any method of controlling the voltage is satisfactory which does not distort the wave more than 10 percent from a sinusoidal shape.

**4.6.2.3 Voltage measurement.** - The voltage may be measured by any method which gives root-mean-square values, preferably by means of a voltmeter connected to a tertiary coil in the testing transformer, or to a separate step-down instrument potential transformer. 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. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

#### **4.6.2.4 Test electrodes.**

**4.6.2.4.1 Forms F and S.** - The test electrodes for forms F and S materials shall consist of metal cylinders 2 inches in diameter and not less than 1/2 inch in length, with edges rounded to a radius of 1/4 inch. The total weight on the sample shall be approximately 1 pound.

**4.6.2.4.2 Form T.** - The test electrodes for form T material shall consist of bars 4 inches long and 1/4 inch wide, rounded at the ends, and with all edges in contact with the sample rounded to a radius of 1/32 inch. The total weight on the sample shall be approximately 1/2 pound.

**4.6.2.4.3 Form U.** - The test electrodes for form U material shall consist of a solid conductor which fits the inside of the tubing closely without stretching the tubing, and tightly wrapped 1-inch strip of metal foil on the outside. In the case of flexible tubing of 0.315-inch inside diameter and larger, the tubing may be cut along its axis, flattened, and tested with the electrodes specified in 4.6.2.4.2.

#### **4.6.2.5 Specimens.** - Pieces shall be cut as follows:

Forms	Size
F and S	3-1/2 inches by 7 inches
T	12 inches by width of sample
U	12 inches long

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Each of the pieces shall be cut in half crosswise 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.

#### 4.6.2.6 Procedure. -

4.6.2.6.1 Tests shall be made at 23°C. with the specimen immersed in temperature-controlled transformer oil conforming to Specification VV-1-530. This oil shall be changed frequently to prevent excessive deterioration. The test electrodes shall be kept clean and polished. They shall be self-aligning, and shall be placed exactly opposite one another, with the specimen in a horizontal plane between them.

4.6.2.6.2 Starting at zero, the voltage shall be increased uniformly to a breakdown, at a rate of 500 volts per second. The average dielectric break-down of the material shall be expressed in volts. The dielectric strength shall be computed by dividing the average dielectric break-down by the average thickness and shall be reported in volts per mil. The average thickness shall be determined as specified in 4.6.1.2.3 and hence will be the same in calculation of dielectric strength for both conditions C-96/23/0 and C-96/23/96.

#### 4.6.3 Dissipation factor and dielectric constant<sup>1</sup> (forms F, S, and U only). -

4.6.3.1 Test equipment. - The test equipment shall be a suitable bridge or resonant-circuit.

4.6.3.1.1 Bridge method. - The bridge or bridges used shall be suitable for the measurement of dissipation factor and dielectric constant at the specified frequencies. Five bridge arrangements which have been found satisfactory for the purpose intended are the "Conjugate Schering Bridge", the "High Voltage Schering Bridge", the "Parallel Resistance Bridge", the "Series Resistance Bridge", and the "Transformer Bridge". It is not intended, however, that the use of other types of bridges of equal precision and convenience be excluded.

4.6.3.1.2 Resonant-circuit method. - The resonant circuit used shall be of a type suitable for the measurement of dissipation factor and dielectric constant at 1 megacycle. Three resonant-circuit arrangements which have been found satisfactory for the purpose intended are the "Susceptance Variation", the "Resistance Variation", and "Resonant Rise". It is not intended, however, that the use of other types of resonant circuit arrangements of equal precision and convenience be excluded.

4.6.3.1.3 Sensitivity. - The method used shall have an accuracy of determination of dielectric constant of plus or minus 5 percent, and an accuracy of determination of dissipation factor of plus or minus 5 percent of 0.0002, whichever is greater.

4.6.3.2 Specimens. - Where possible, specimens should be in the form of flat square sheets. Larger sizes (1 inch or greater) of tubing may be slit along the axis of the tubing and flattened to obtain the sheet specimen. Small tubing shall be tested in full section.

4.6.3.3 Electrodes. - In most cases metal foil electrodes will be satisfactory and where possible a guard ring shall be employed. In this case the unguarded electrode shall be a disk of a diameter slightly less than the specimen width while the guarded electrode shall have a diameter equal to about 75 percent of the diameter of the unguarded electrode. The guard ring shall extend almost to the edge of the specimen and shall be of such size as to leave as narrow a space between guard ring and guarded electrode as is mechanically feasible. In any case the radial width of the guard ring shall be not less than five times the thickness of the specimen. The electrodes shall be applied to the specimen by using a very thin film of petrolatum thoroughly rolling the electrodes, so applied, to exclude air. The electrodes shall be accurately centered with respect to each other. On materials less than 0.005 inch in thickness vacuum deposited electrodes may be used for greater accuracy. Suitable coaxial electrodes may be used on small tubing.

#### 4.6.4 Volume resistivity. -

##### 4.6.4.1 Forms F and S only. -

4.6.4.1.1 Apparatus. - The apparatus shall consist of a source of direct-current (d. c.) potential of 100 to 200 volts, a galvanometer with suitable shunts having a minimum sensitivity of 0.0005 microampere

<sup>1</sup> For a complete discussion of the theory, apparatus, electrodes, procedure, and calculations, refer to ASTM D150.

per millimeter at one meter-scale distance, a calibrated resistance, reversing switches, and keys. Any other apparatus may be used provided the same accuracy is obtained and the same voltage is applied.

4.6.4.1.2 Specimens. - The size of the test specimens shall be 4 by 4 inches by thickness.

4.6.4.1.3 Electrodes. - The electrodes shall be as specified in 4.6.3.3.

4.6.4.1.4 Procedure. - The electrodes shall be applied to the specimen, and the volume resistance between the guarded and unguarded electrodes shall be measured by means of a test set which applies approximately 180 volts d. c. to the specimen. The reading shall be taken after voltage has been applied for 1 minute.

4.6.4.1.5 Calculation. - Volume resistivity,  $r$  in ohm-centimeters, shall be calculated as follows:

$$r = \frac{RA \times 10^6}{t}$$

Where:

R = volume resistance in megohms.

A = area of guarded electrode in square centimeters.

t = average thickness of specimen in centimeters.

4.6.4.2 Form U (type F only). -

4.6.4.2.1 Apparatus. - The apparatus shall consist of that specified in 4.6.4.1.1; in addition, there shall be a container for water large enough to accommodate a specimen of tubing bent into a U-shape, and a support for the two branches of the U-shaped tubing.

4.6.4.2.2 Specimens. - The test specimens shall be cut sufficiently long so that a satisfactory reading may be obtained on the galvanometer. The minimum length shall be 2 feet.

4.6.4.2.3 Procedure. - The specimen shall be shaped without kinking into a U-form and immersed in water, at  $23 \pm 2^\circ\text{C}$ ., containing 1 percent sodium chloride. Not less than 1 foot of the specimen shall be submerged. To prevent leakage of electric current the ends of the specimen shall protrude 6 inches above, and approximately perpendicular to the surface of the water. The specimen shall be filled immediately with the same salt water, and, as a precaution against air bubbles and discontinuity of the water phase, a fine wire shall be inserted throughout the length of the specimen. The salt water in the tubing shall serve as an inner electrode, and its surface shall be above the surface of the salt water in the container. The salt water in the container shall serve as an outer electrode. The specimen shall remain in the water for 24 hours. At the end of this time the reading shall be taken.

4.6.4.2.4 Calculation. - Volume resistivity,  $r$ , in ohm-centimeters, shall be calculated as follows:

$$r = \frac{RL \times 10^6}{0.3663 \times \log \frac{(D)}{d}}$$

Where:

R = volume resistance in megohms.

L = length of specimen in centimeters.

D = outside diameter.

d = inside diameter.

Note. - Log is to the base 10.

4.6.5 Tensile strength, elongation, and percent return. -

4.6.5.1 Tensile strength and elongation. -

4.6.5.1.1 Apparatus. - Tensile strength and elongation shall be determined on an approved pendulum-type or constant rate of elongation testing machine. The machine shall preferably be power-driven.

4.6.5.1.2

**Specimens** - Specimens of each size of material shall be tested after being subjected to conditions C-96/23/50, E-400/100, and E-400/130 when required in tables I, II and III. Specimens cut from form F, and from forms S and T measuring 0.010 inch and less in thickness, shall be 1 inch wide. Specimens cut from forms S and T measuring more than 0.010 inch in thickness shall be 1.2 inch, dumbbell die-cut specimens, except that tape less than 1-1.2 inches wide shall be tested in full section. Form U tubing of 0.315-inch inside diameter and larger shall be tested by using a 2-inch dumbbell die-cut specimens. Form U tubing in smaller size inside diameters shall be tested in full tubing section.

**4.6.5.1.3 Procedure** -

**4.6.5.1.3.1 Bench marks** 10 inches apart shall be used for materials having ultimate elongations of 25 percent or less. Bench marks 2 inches apart shall be used for materials having ultimate elongations greater than 25 percent. On aged specimens, bench marks shall be applied prior to aging.

**4.6.5.1.3.2 The test specimens** shall be placed in the testing machine and stretched until they break. The rate of separation of the jaws of the machine shall be  $12 \pm 1/2$  inch per minute. A scale shall be used to measure the elongation at the instant of rupture. The tensile strength shall be reported in pounds per square inch.

**4.6.5.2 Percent return** (type F, form S, and subform T<sub>5</sub> only) - The tests shall be conducted on specimens similar to those specified in 4.6.5.1.2 which have been subjected to condition C-96/23/50.

**4.6.5.2.1 Procedure** -

**4.6.5.2.1.1 The specimens** shall be stretched an amount equal to 50 percent of the elongation value after condition C-96/23/50, obtained when tested as specified in 4.6.5.1.3.2. The stretch shall be maintained for 100 seconds, and the material shall be allowed to recover for 60 seconds. The distance between bench marks and the rate of elongation shall be as specified in 4.6.5.1.3.1.

**4.6.5.2.1.2 Calculation** - The percent return shall be expressed as the distance returned, multiplied by 100 and divided by the distance stretched.

**4.6.6 Bursting strength** (type F, subform U<sub>5</sub> only) -

**4.6.6.1 Apparatus and specimens** - Bursting strength shall be measured on 9-inch lengths of tubing clamped over a source of compressed air at one end and plugged at the other end in such a manner that the clamps are 6 inches apart and the tubing cannot expand in a lengthwise direction.

**4.6.6.2 Procedure** -

**4.6.6.2.1 Increasing pressure** - The pressure shall be increased in steps of 1 pound at the rate of 5 pounds per minute, until failure.

**4.6.6.2.2 Continuous pressure** - The pressure shall be increased in steps of 1 pound at the rate of 5 pounds per minute, until the desired continuous pressure shown in table III is attained. This pressure shall be maintained for 24 hours.

**4.6.7 Softening temperature (penetration)** -

**4.6.7.1 Apparatus** - The apparatus shall consist of an oven capable of raising the temperature of a stainless steel plate  $1/8$  by  $1-1/4$  inches, at the rate of 1 C. every 2 minutes; a  $1/16$ -inch magnetized steel rod, recessed at one end to hold a  $1/16$ -inch ball, in contact with and equipped to exert a pressure of 1,000 grams vertically down against the stainless steel plate, lying in a horizontal plane; an electrical circuit with a 110-volt source of electricity, a 110-volt glow lamp, and a suitable means of measuring the temperature of the steel plate as near the point of test application as practicable. The use of a thermocouple to measure this temperature is suggested. Equipment as shown on figure 1 is recommended. The light C-clamp, containing the steel rod, counterbalance and weight, shall be mounted on a bearing capable of giving the unit the necessary freedom of clockwise motion. With no load on the lower leg of the C-clamp, the counterbalance shall be adjusted to neutralize the pressure of the ball against the steel plate.

**4.6.7.2 Specimens** - One-inch long specimens shall be cut from the sample and prepared for test. For tubing, this may be accomplished by opening one side along the longitudinal axis.

4.6.7.3 Procedure. - With no load on the rod, each specimen shall be inserted between the steel ball and steel plate; tubing shall be inserted with its outside surface facing the plate. The electrical circuit shall be connected in such a way that when the steel ball comes in contact with the plate, the lamp contained outside the oven will light. The specimen in the oven at room temperature shall then be put under a compression load of 1,000 grams. The temperature of the steel plate shall be uniformly raised at the rate of 1°C every 2 minutes until failure of the specimen, which is indicated by the lighting of the lamp. The temperature at failure shall then be recorded as the softening temperature (penetration), to determine compliance with the applicable requirements of table I, II, or III.

#### 4.6.8 Lengthwise shrinkage. -

4.6.8.1 Specimens. - Specimens of each size of material, in strips 1/2 inch wide by 6 inches long with 5 inches between bench marks, shall be tested. Strips cut from forms F and S material shall be used. Tape and tubing shall be tested in full sections.

#### 4.6.8.2 Procedure. -

4.6.8.2.1 Forms F, S, and T. - The specimens shall be supported in an oven by a smooth-surfaced, thin metal plate covered with talc, and subjected to condition E-2/100 or E-2/150, as specified in tables I and II. The specimens shall then be removed and cooled to room temperature (23°C.). The length of the material shall be measured before and after heating, and the percentage of shrinkage calculated from these values.

4.6.8.2.2 Form U. - The specimens shall be supported by insertion of a solid conductor having a diameter slightly less than the inside diameter of the tubing, and well coated with talc to prevent bonding. The specimens so supported shall be held horizontally in an oven and subjected to condition E-2/100 or E-2/150, as specified in table III. The specimens shall then be removed and cooled to room temperature (23°C.). The length of the material shall be measured before and after heating and the percent shrinkage calculated from these values.

4.6.9 Effect of heat on material under tension (type F, form S, and subform T<sub>a</sub> only). - Brass tubing approximately 1 inch in diameter and 3-3/4 inches long shall be wrapped with two half-lapped windings of material approximately 1 inch wide under a tension of 500 pounds per square inch, and the end secured. The specimens shall be subjected to condition E-400/100 and examined at intervals for cracking or splitting of layers.

#### 4.6.10 Flexibility after aging. -

4.6.10.1 Specimens. - A sufficient number of 1-inch-wide strips of forms F and S material and of form T tape wider than 1 inch shall be used so that samples can be discarded after bending. Tape 1 inch wide and less, and form U tubing without conductor inside, shall be tested in full section.

4.6.10.2 Procedure. - Specimens of type G shall be subjected to condition E-200/150 in a forced-draft oven. Specimens of all other types shall be subjected to condition E-200/100 in a forced-draft oven. The specimens shall then be cooled to room temperature (23°C.), and bent as follows:

Forms F, S, and T. - The material shall be bent 180 degrees around a mandrel of a diameter equal to its own thickness.

Form U. - The tubing, in full section without conductor inside, shall be bent 180 degrees around a 1/8-inch diameter mandrel.

#### 4.6.10.3 Ultra-violet-light aging (type F, form U, grade b only). -

4.6.10.3.1 Apparatus. - The specimens shall be secured to a light-colored, corrosion-resistant metal disk, approximately 17 inches in diameter and 0.1 inch in thickness, mounted on a turntable operating at 33 revolutions per minute. The disk shall be centered under an S-1 bulb which has been in use not less than 30 hours and not more than 550 hours, and which is mounted in a General Electric sun lamp, model BM13, or an equivalent lamp, equipped with a reflector approximately 15 inches in diameter at the lower rim. The lamp and turntable shall not be enclosed. The plane of the specimens shall be 6 inches from the bottom of the bulb.

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4.6.10.3.2 Mounting of specimens. - The specimens shall be supported about 3/16 inch above the surface of the disk by a wire screen. Specimens shall be 4 inches long by not more than 1-1/2 inches in width or diameter. The specimens shall be mounted radially with their inside end 3 inches from the center of the disk.

4.6.10.3.3 Procedure. - After exposure to the ultraviolet radiation for 120 hours, the specimens shall be removed and bent as specified in 4.6.10.2.

4.6.11 Cold bend (applicable only to forms F, S, and T). -

4.6.11.1 Specimens. - Strips of film, sheet and tape, 1 inch wide shall be used. Tape less than 1 inch wide shall be tested in full width.

4.6.11.2 Procedure. - Specimens shall be conditioned for 1 hour in air at -23°C. All specimens shall be bent while at the required temperature, as specified in 4.6.10.2.

4.6.12 Cold brittleness (form U only). -

4.6.12.1 Specimens. - For tubing 0.148-inch inside diameter and larger test specimens 1/4 inch in width and 1-1/2 inches in length shall be cut from the tubing. This shall be accomplished by cutting a 1/4 inch strip along a longitudinal axis of the sample. For tubing smaller than 0.148-inch inside diameter, test specimens in full section 1-1/2 inches in length shall be cut from the tubing.

4.6.12.2 Apparatus. - The apparatus shall be in accordance with method 2051 of Specification L-P-406 except that the brittleness testing machine shall be motor-driven. The dimensional requirements between specimen clamp and striking edge are shown in figure 2.

4.6.12.3 Procedure. - For qualification testing, 10 specimens shall be tested at each temperature starting at the estimated brittle temperature in accordance with the procedures of method 2051 of Specification L-P-406. Two-degree C. temperature intervals shall be used and the above range shall be completely covered. For acceptance testing, the number of specimens shall be as specified in 4.4.1.3 for each lot as defined in 4.4.1.1. When there is more than one sample of any one type or size, the 18 specimens shall be equally distributed between these samples. The specimens shall be immersed in the coolant at the applicable temperature in table III plus or minus 0.5°C. for  $2.5 \pm 0.5$  minutes and the blow delivered.

4.6.12.4 Evaluation. - Failure is defined as the separation of the specimen into two or more separate pieces. The occurrence of fissures or cracks does not constitute brittle type failure although their presence shall be reported. For qualification tests the 50 percent brittle temperature shall be calculated as in method 2051 of Specification L-P-406. For acceptance testing, failure of three or four of the four specimens representing any length of tubing shall be counted as a failure of that piece, and therefore, of the lot represented.

4.6.13 Flame resistance (type F, form U only). -4.6.13.1 Test apparatus. -

4.6.13.1.1 Sheet-metal enclosure. - A three-wall sheet-metal enclosure, 12 inches wide by 14 inches long by 29 inches high, shall be used. The walls facing each other shall support two parallel horizontal steel rods; these rods of 1/4 inch diameter shall be separated 16 to 21 inches as required, with the lower rod closer to the back wall, and shall be located so that they define a plane which shall be set at an angle of 70 degrees to the horizontal.

4.6.13.1.2 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 attached to maintain the wire in a straight line across the two rods.

4.6.13.1.3 Tirrill burner. - A Tirrill burner having a nominal bore of 3/8 inch and a length of approximately 4 inches above the primary inlets, with an attached pilot light, shall be used.

4.6.13.1.4 Gas supply. - A supply of ordinary illuminating gas at normal pressure shall be available.

4.6.13.1.5 Timer. - A timer measuring seconds shall be used.

4.6.13.1.6 Flame indicators. - Strips of gummed paper shall be used as flame indicators.

4.6.13.2 Test specimens. - For inside diameters of 7/8 inch and less, test specimens 17 inches long shall be cut from the sample. For inside diameters of more than 7/8 inch, test specimens 22 inches long shall be cut from the sample.

4.6.13.3 Procedure. -

4.6.13.3.1 For round tubing. -

4.6.13.3.1.1 Preparation. - The test shall be made in a room or cabinet free from drafts of air. The specimen shall be drawn onto the wire. The covered wire shall be fastened into position, with its length adjusted so that the weight hangs free, maintaining tension and supporting the specimen in a straight line at an angle of 70 degrees with 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 clamped so that the specimen is closed, in order to prevent a draft through the tube. The paper indicator shall be applied to the upper end of the specimen, in such a position that, for tubing 7/8 inch and less in inside diameter, the lower edge is 10 inches away from the point at which the inner cone of the test flame is to be applied. For tubing more than 7/8 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.

4.6.13.3.1.2 Application of flame. - The height of the flame with the burner in a vertical position shall be adjusted to 5 inches with an inner cone of 1-1/2 inches high. The burner, with only the pilot lighted, on a base at an angle of 25 degrees with the horizontal, shall be placed in such a position under the specimen that the axis of the burner makes an angle of 45 degrees with the specimen and 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 stem. The valve controlling the gas supply shall be opened, and the flame applied to the specimen for 15 seconds.

4.6.13.3.2 For flat tubing. -

4.6.13.3.2.1 Preparation. - 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 specimen shall be between the tip of the stem and the surface of the narrow side of the flat specimen.

4.6.13.3.2.2 Application of flame. - The valve controlling the gas supply to the burner shall be opened, and the flame shall be applied to the narrow side of the specimen for a period of 15 seconds. The duration of burning shall be determined immediately after removal of the flame.

4.6.13.3.3 Calculation. - The length of specimen burned shall be determined by subtracting the length of the unburned portion from the original length of the test specimen. The unburned portion is the distance from the lower edge of the indicator paper to the first obvious defect caused by the flame.

4.6.14 Oil resistance-flexibility (not applicable to types A and D). -

4.6.14.1 Specimens. - The specimens in forms F, S, and T shall be strips 8 inches long. Form U specimens shall be 18 inches long.

4.6.14.2 Apparatus. - Tests on material in forms F, S, T, and U shall be made in a closed container approximately 6 inches deep, filled with Type VI high-swelling oil conforming to Specification MIL-S-3136 to a line 2 inches below the cover. Strips of material in forms F, S, and T shall be hung in straight lengths with one end protruding through the cover and the lower end below the surface of the oil. Specimens of material in form U shall be bent in the shape of a U around a diameter of approximately 4 inches, with the ends protruding through the cover and the bottom of the U located 3 inches below the surface of the oil. The specimen then has a section immersed in oil, a section in oil vapor, and a section above the cover subjected to oven temperature only.

4.6.14.3 Procedure. - The entire equipment shall be subjected to condition E-200/50. The specimens shall then be removed and tested to determine compliance with 3.5.5.

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4.6.15 Corrosive effect. - Forms F, S, and T shall be tested by full-wrapping a 3/8-inch strip full length and return on a 6-inch piece of 0.162-inch diameter (AWG No. 6) copper wire. Form U tubing of 0.315-inch inside diameter, and larger, shall be slit lengthwise to form tape 3/8 inch wide. The tape shall be wrapped on the copper wire as above. Tubing of less than 0.315-inch inside diameter shall be tested by inserting the proper size wire into a 6-inch length of the tubing. A 30-inch length of 0.006-inch diameter, bare copper wire in a bifilar winding shall then be wrapped over the prepared specimens. If wrapped in the proper manner, the bifilar winding will not cross the edges of the specimen strip at any point. The ends of the wire shall be welded to heavy leads of 0.040-inch diameter (AWG No. 18) copper wire, and the sample placed in a test tube with the leads extending through a cork. A small amount of distilled water shall be placed in the test tube to maintain a high relative humidity, and the cork shall be coated to produce a vapor-tight seal. The entire equipment shall be placed in an oven maintained at 70°C. The resistance of the 0.006-inch diameter copper wire shall be measured when the temperature of the specimen reaches 70°C. and at 24-hour intervals for 720 hours. At the end of this period, specimens shall be examined for visual evidence of corrosion on the 0.006-inch diameter wire and the increase in resistance of the wire shall be reported in percent. Percentage change in resistance versus time shall be plotted to show corrosion characteristics of the material.

4.6.16 Fungus resistance (class I only). -

4.6.16.1 Test fungi. - The following test for fungi (see 6.4) shall be used:

	American type culture collection number
Aspergillus niger .....	9642
Aspergillus flavus .....	9643
Penicillium luteum .....	9644
Trichoderma T-1 .....	9645

Cultures of these fungi shall be maintained separately on an appropriate medium, such as potato-dextrose agar. The stock cultures may be kept for not more than 4 months in a refrigerator, at approximately 3° to 10°C. Subcultures incubated at 28° to 30°C., for 7 to 20 days, shall be used in preparing the spore suspension.

4.6.16.2 Spore suspension. - A separate sterile 10 milliliter (ml.) portion, of distilled water or of a solution containing per liter 0.05 gram of a nontoxic wetting agent such as dioctyl sodium sulfosuccinate, shall be poured into one subculture of each of the four fungi and agitated to dislodge the spores. The resulting separate spore suspensions shall be mixed to provide a composite spore suspension for use in the test. The spore suspension shall be prepared freshly upon the day of the test.

4.6.16.3 Controls. - The viability of the inoculum shall be checked with each composite spore suspension, upon each day when it is used for inoculation. Three agar slants, of an appropriate medium such as potato-dextrose agar, shall serve as controls. A drop of the composite spore suspension shall be deposited with aseptic precautions at the top of each slant. The controls shall then be incubated with the test specimens. The spore suspension shall be considered satisfactory provided all three controls are covered with fungus growth at the end of the incubation period of 21 days.

4.6.16.4 Specimens. - Specimens of film, sheet, or tape shall consist of portions approximately 1-1/2 inches square. Specimens of large-size tubing shall be 1-1/2 inch squares cut from the tubing; specimens from small-diameter tubing shall be 1-1/2-inch lengths cut from the tubing.

4.6.16.5 Procedure. - The test medium shall contain 20 grams of agar and 1,000 ml. of distilled water. Each test specimen shall be placed in the center of a petri dish containing approximately 25 ml. of solidified test medium. The specimens shall then be sprayed with the mixed spore suspension (see 4.6.16.2). The inoculated specimens shall be incubated for 21 days at 28° to 30°C.

4.6.16.6 Evaluation of results. - At the end of the 31-day incubation period, each specimen shall be examined and rated as follows:

Observed fungus growth on the specimen	Rating
No growth.....	0
Traces of growth <sup>2/</sup> .....	1
Partial coverage, slight to moderate growth.....	2
Moderate growth, considerable coverage.....	3
Abundant growth, complete coverage.....	4

4.6.17 Chemical analysis. - A chemical analysis shall be performed to determine the relative proportions and the general type of the basic resin, the plasticizing agents, and the pigments or loading materials, comprising the finished compound. Specific gravity, refractive index, where practicable and solubility, in organic solvents shall also be determined. (Benzene, petroleum ether, acetone, and carbon tetrachloride shall be considered as representing aromatic, aliphatic, oxygenated and chlorinated solvents, respectively.)

4.6.18 Storage stability (type F, form U only). - Specimens approximately 8 inches long of each size of tubing shall be examined carefully for surface condition and then placed in a 1 quart clamp-top mason jar. The top of the jar shall then be clamped on without the rubber ring in place (so that the jar will not be sealed). The jars shall then be stored in a dark cabinet at 23°C. and 50 percent relative humidity for a period of 12 months. Specimens shall be examined monthly for evidence of spewing (oily or sticky exudation). At the end of the 12-month period, type F, form U, class 1 material shall be tested for fungus resistance as specified in 4.6.16.

## 5. PREPARATION FOR DELIVERY

5.1 Packaging. - Packaging shall be level A or C as specified (see 6.2).

### 5.1.1 Level A. -

5.1.1.1 Form F (film). - Each roll shall be individually wrapped in not less than 30-pound basis weight kraft paper, waxed on one side only (waxed side out), and securely sealed with 2-inch width, water-resistant tape conforming to type III, class 2 of Specification PPP-T-60. The tape shall be applied in such lengths that it will entirely surround the roll and lap on itself at least 2 inches. Rolls shall be further packaged individually in a suitable style corrugated or solid fiberboard box conforming to Specification PPP-B-636. Adequate double faced corrugated pads shall be used to protect the ends of the rolls against damage in shipment and storage. Wrapped rolls may, when required by the bureau or agency concerned, be packaged individually in snug-fitting cylindrical containers, securely capped and sealed.

5.1.1.2 Form T (tape). - Tape shall be tightly wound in rolls on cores. A number of rolls placed end to end, sufficient to approximate a 24-inch length separated from each other by cardboard disks, shall be wrapped in 30-pound basis weight kraft paper, waxed on one side only (waxed side out), and securely sealed with 2-inch width, water-resistant tape conforming to type III, class 2 in Specification PPP-T-60. The tape shall be applied in such lengths that it will entirely surround the roll and lap on itself at least 2 inches. Wrapped rolls of tape (approximately 24 inches in length) shall be further packaged individually in a suitable style corrugated or solid fiberboard box conforming to Specification PPP-B-636.

5.1.1.3 Form S (sheet). - When furnished in rolls, form S insulation shall be packaged in conformance with 5.1.1.1 or 5.1.1.2 as applicable. Flat sheets when furnished shall be adequately protected against damage in shipment and storage by the use of chipboard separators. They shall be wrapped in 30-pound basis weight kraft paper, waxed on one side only (waxed side out), and securely sealed with 2-inch width, water-resistant tape conforming to type III, class 2 of Specification PPP-T-60. The tape shall be applied in such lengths that it will entirely surround the roll and lap on itself at least 2 inches.

<sup>2/</sup> Traces of growth may be defined as scattered, sparse fungus growth such as might develop from an unusual mass of spores in the original inoculum, or upon an occasional extraneous bit of debris. (Continuous cobwebby growth, extending over the entire surface of the specimen, even though not necessarily obscuring the specimen should be rated as 2.)

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5.1.1.4 Form U (tubing). - Reels of tubing shall be individually wrapped in not less than 30-pound basis weight kraft paper, waxed on one side only (waxed side out), and securely sealed with 2-inch width, water-resistant tape conforming to type III, class 2 of Specification PPP-T-60. The tape shall be applied in such lengths that it will entirely surround the roll and lap on itself at least 2 inches. Reels of tubing shall be further packaged in suitable style corrugated or solid fiberboard boxes conforming to Specification PPP-B-636.

5.1.2 Level C. - Insulation shall be packaged in accordance with the supplier's commercial practice.

5.2 Packing. - Shipping containers shall contain an identical number of items of one type, form, grade, class, size, and color. Packing shall be level A, B, or C as specified (see 6.2).

5.2.1 Level A. - Insulation, packaged as specified (see 6.2), shall be packed in any container specified in the following specifications at the option of the contractor.

Specification	Type or class
PPP-B-576	Class 3
PPP-B-585	Class 3 use
PPP-B-591	Overseas type
PPP-B-601	Overseas type
PPP-B-621	Class 3
PPP-B-636	Class 2

Box closure and strapping shall be in accordance with the applicable box specification or appendix thereto, except that fiber boxes may be banded with reinforced filament tape in accordance with the appendix to Specification PPP-B-636. The gross weight of wood boxes shall not exceed 200 pounds.

5.2.2 Level B. - Insulation, packaged as specified (see 6.2) shall be packed in any container specified in the following specifications at the option of the contractor:

Specification	Type or class
PPP-B-576	Class 1
PPP-B-585	Class 1 or 2 use
PPP-B-591	Domestic type
PPP-B-601	Domestic type
PPP-B-636	Class 2

Box closure shall be as specified in the applicable box specification or appendix thereto. The gross weight of wood boxes shall not exceed 200 pounds.

5.2.3 Level C. - Insulation, packaged as specified (see 6.2), shall be packed in a manner which will insure acceptance by common carrier and safe delivery at destination. Shipping containers or method of packing shall conform to the Uniform Freight Classification Rules or other carrier regulations as applicable to the mode of transportation.

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

## 6. NOTES

### 6.1 Intended use. -

6.1.1 Type A. - This type of material is intended for ultra high-frequency applications. It possesses excellent electrical properties which remain practically constant over a wide range of frequencies, temperatures, and humidities, and has a very low loss factor.

6.1.2 Type B. - This type of material is intended for applications requiring a good dielectric strength, fairly low loss factor, good moisture resistance, and good insulation resistance.

6.1.3 Type C. - This type of material is intended for applications requiring good dielectric strength, fairly low loss factor, and a relatively high degree of heat resistance with some sacrifice in moisture resistance.

6.1.4 Type D. - This type of material is intended for radio-frequency applications requiring very good dry dielectric strength, fairly low loss factor, and fair moisture resistance.

6.1.5 Type E. - This type of material is intended for applications having excellent mechanical strength and excellent bursting strength. It is intended for general-purpose electrical applications but is more rigid than type F.

6.1.6 Type F, grade a. - This type of material is intended as a high-elongation, elastic material with good electrical properties, suitable as an alternate for rubber insulating tape in cable or other applications.

6.1.7 Type F, grade b. - This type of material is intended as a high-elongation, elastic material similar to type F, grade a, with less rigidity at low temperatures and other characteristics required for aeronautical applications.

6.1.8 Type F, grade c. - This type of material is intended as a high-elongation, elastic material similar to type F, grade a, but suitable for operation at higher temperatures (105°C.).

6.1.9 Type G. - This type of material is intended for applications requiring good dielectric strength, fairly low loss factor, excellent mechanical strength and heat resistance.

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

- (a) Title, number, and date of this specification.
- (b) Type required. (See 1.2.)
- (c) Form required, and whether form S is to be furnished flat or in rolls. (See 3.3.)
- (d) Grade required for type F. (See 1.2.)
- (e) Class required. (See 1.2.)
- (f) Color, if required. (See 3.2.4.) Available colors include those specified in table XIV.

Table XIV. - Available colors.

Type	Form F and subform T <sub>f</sub>	Form S and Subform T <sub>s</sub>	Form U
A		Natural (unpigmented but slightly tinted)	Natural (unpigmented but slightly tinted) black, white, or red.
B	Clear transparent	Clear transparent	
C	Clear transparent	Clear transparent	
D	Clear transparent	Clear transparent	
E		Natural (yellowish)	Natural (yellowish)
F		Black	Black, white, red, blue or transparent (clear or slightly tinted).
G	Clear transparent	Translucent	.....

- (g) Dimensions required. (See 3.3):
  - Forms F, S, and T:
    - Thickness, width, and length of material on roll.
    - Diameter of roll and mandrel.
  - Form U:
    - Number of feet required.
    - Number of feet in single reel. (See 3.3.4.)
    - Nominal inside diameter thickness. (See tables VIII or IX.)

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Nominal wall thickness. (See table VIII or IX.)

Size number for AWG-size tubing. (See table VIII.)

- (h) Whether Form T is for application by hand or machine. (See 3.3.3.)
- (i) Number of pounds required for forms F, S, and T.
- (j) Level of packaging and level of packing required (see 5.1 and 5.3)

6.2.1 Procurement documents should specify that bidders shall submit with their bids a statement in triplicate showing:

- (a) Diameter of roll or reel in inches.
- (b) Weight of roll or reel.
- (c) Number of feet per roll or reel.
- (d) Number of feet per pound of material.

6.3 With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List QPL-631, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification, in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the Bureau of Ships, Department of the Navy, Washington 25, D. C., and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 5.4).

6.4 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia 20, Pennsylvania

6.5 Sources of stock fungus cultures. - The test fungi designated for use in tests may be obtained from the American Type Culture Collection, 2029 M Street, N. W., Washington 6, D. C.

6.6 Suggested weights per roll and feet per roll—forms F, S, and T. - For information of purchasing activities, suggested weights per roll and feet per roll of forms F, S, and T (machine taping only) material are specified in table XV.

Table XV. - Suggested weights per roll and feet per roll (forms F, S and T (machine taping)).

Width (inches)	Pounds per roll		Approximate feet per roll times thickness in inches <sup>1/</sup>			
	Type A	Other types	Types A and F, grade a	Types B, C, and G	Type D	Type E
0.50	0.35	0.50	1.80	1.66	1.93	1.27
.75	.525	.75	1.80	1.66	1.93	1.27
1.00	.70	1.00	1.80	1.66	1.93	1.27
1.25	.875	1.25	1.80	1.66	1.93	1.27
1.50	1.05	1.50	1.80	1.66	1.93	1.27
2.00	1.40	2.00	1.80	1.66	1.93	1.27
2.50	1.75	2.50	1.80	1.66	1.93	1.27
3.00	2.10	3.00	1.80	1.66	1.93	1.27
6.00	4.20	6.00	1.80	1.66	1.93	1.27
12.00	8.40	12.00	1.80	1.66	1.93	1.27
24.00	16.80	24.00	1.80	1.66	1.93	1.27
36.00	25.20	36.00	1.80	1.66	1.93	1.27

<sup>1/</sup> Feet per roll can be obtained by dividing by thickness in inches.

6.7 Signal Corps restriction on use of "spaghetti" tubing. - Form U insulation, often called "spaghetti" tubing, should be used on Signal Corps equipment only with the express approval of the contracting officer.

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6.8 Table D is for use by Department of Navy personnel when applying tubing in Navy applications covered by Drawing S6202-73980, Sec. IV

**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.

**Custodians:**

Army - Sig  
Navy - Ships  
Air Force - DAY

**Preparing activity:**

Navy - Ships  
(Project 5970-0048)

