

INCH-POUND
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MIL-W-22759 E  
 31 December 1990  
 SUPERSEDING  
 MIL-W-22759D  
 29 June 1973

## MILITARY SPECIFICATION

### WIRE, ELECTRICAL, FLUOROPOLYMER-INSULATED, COPPER OR COPPER ALLOY

This specification is approved for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

\* 1.1 Scope. This specification covers fluoropolymer-insulated single conductor electrical wires made with tin-coated, silver-coated, or nickel-coated conductors of copper or copper alloy as specified in the applicable specification sheet. The fluoropolymer insulation of these wires may be polytetrafluoroethylene (TFE), fluorinated ethylene propylene (FEP), polyvinylidene fluoride (PVF<sub>2</sub>), ethylene-tetrafluoroethylene copolymer (ETFE), or other fluoropolymer resin. The fluoropolymer may be used alone or in combination with other insulation materials.

1.2 Classification. The wires are as described in the applicable specification sheet and as identified by the specification sheet number and title.

1.2.1 Part numbers. Part numbers under this specification are coded as in the following example:

<u>M22759/1</u>	-	<u>22</u>	-	<u>9</u>
Applicable specification sheet (see 3.1)		Wire size (see Table II)		Insulation color designator (see 3.6.4)

1.2.2 Temperature ratings of finished wires. The maximum conductor temperatures of the finished wires for continuous use are as specified in the specification sheets (see 6.1.1).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 53), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.
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AMSC N/A

FSC 6145

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## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto cited in the solicitation (see 6.2).

## SPECIFICATIONS

## FEDERAL

TT-I-735 - Isopropyl Alcohol

## MILITARY

- \* MIL-W-5088 - Wiring, Aerospace Vehicle
- MIL-H-5606 - Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance
- MIL-T-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5
- MIL-C-12000 - Cable, Cord, and Wire, Electric; Packaging of
- MIL-L-23699 - Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

(See Supplement 1 for list of associated specification sheets.)

## STANDARDS

## FEDERAL

FED-STD-228 - Cable and Wire, Insulated; Methods of Testing

## MILITARY

- MIL-STD-104 - Limits for Electrical Insulation Color
- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-109 - Quality Assurance Terms and Definitions
- MIL-STD-129 - Marking for Shipment and Storage
- MIL-STD-202 - Test Methods for Electronic and Electrical Components Parts
- MIL-STD-681 - Identification Coding and Application of Hookup and Lead Wire
- \* MIL-STD-45662 - Calibration Systems Requirements

(Unless otherwise indicated, copies of federal and military specifications, standards and standards are available from the Naval Publications and Forms Center, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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2.1.2 Other government documents. The following other government document forms a part of this specification to the extent specified herein. Unless otherwise specified, the issue shall be the one in effect on the date of the solicitation.

## DEFENSE LOGISTICS AGENCY

## H4/H8 - Catalog of Commercial and Government Entities (CAGE)

(Copies of specifications, standards and other government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

\* 2.2 Non-government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted, shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issues of the non-government documents which are current on the date of the solicitation (see 6.2).

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- \* ASTM B 33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
- ASTM B 298 - Standard Specification for Silver-Coated Soft or Annealed Copper Wire
- ASTM B 355 - Standard Specification for Nickel-Coated Soft or Annealed Copper Wire
- \* ASTM B 624 - Standard Specification for High-Strength, High-Conductivity Copper-Alloy Wire for Electronic Application
- ASTM D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- ASTM D 792 - Standard Methods of Test for Specific Gravity and Density of Plastics by Displacement
- ASTM D 882 - Standard Test Methods for Tensile Properties of Thin Plastic Sheet
- \* ASTM D 4895 - Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced From Dispersion

(Application for copies of ASTM publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

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2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 3. REQUIREMENTS

\* 3.1 Specification sheets. The requirements for the individual wires under this specification shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and those of the specification sheet, the requirements of the specification sheet shall govern, except that all specification sheet provisions concerning resistance to tape abrasion shall be considered as cancelled.

3.2 Classification of requirements. The specification requirements are classified herein as follows:

<u>Requirement</u>	<u>Paragraph</u>
Qualification	3.3
Materials	3.4
Construction	3.5
Finished Wire	3.6
Packaging	3.6.9

3.3 Qualification. The wires furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time set for opening of bids (see 4.4 and 6.3).

### 3.4 Materials.

\* 3.4.1 Conductor material. (For certification of conformity to this requirement before stranding, see 4.1.2 and 4.6.2.1). All strands used in the manufacture of the conductors shall be soft annealed copper conforming to ASTM B 33, ASTM B 298, or ASTM B 355, as applicable, or shall be high strength copper alloy conforming to ASTM B 624. Strands shall be free from lumps, kinks, splits, scraped or corroded surfaces and skin impurities. In addition, the strands shall conform to the following requirements as applicable.

\* 3.4.1.1 Tin-coated copper strands. The strands shall conform to ASTM B 33. There are no additional requirements.

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3.4.1.2 Silver-coated copper strands. The strands shall have a coating thickness of not less than 40 micro-inches of silver when tested in accordance with ASTM B 298.

\* 3.4.1.3 Nickel-coated copper strands. The strands shall have a coating thickness of not less than 50 micro-inches of nickel when tested in accordance with ASTM B 355.

3.4.1.4 High strength copper alloy. The strands shall have such tensile properties that the conductor from the finished wire conforms to the requirements of 3.5.1.3.2 for elongation and tensile breaking strength. The strands shall be silver-coated or nickel-coated in accordance with 3.4.1.2 or 3.4.1.3, as applicable.

3.4.2 Insulating material.

3.4.2.1 Fluoropolymer insulation. All fluoropolymers used in any type of insulation shall be as specified in the applicable specification sheet containing no additives except those required as wetting agents in suspensoids, pigmentation for colors, and lubricants used in extrusion. Fillers shall be added only when required by the applicable military specification sheet. The use of reclaimed or recycled insulation materials is not prohibited, but if used, the recycled materials shall not have been degraded, are free of contaminants, and are identical with materials in performance. When an extruded PTFE insulation is specified on the specification sheet, the PTFE resin shall conform to ASTM D 4895. When tested in accordance with 4.6.2.2 the physical properties of the fluoropolymer insulating materials shall be as specified in Table I.

3.4.2.1.1 TFE coated fibrous glass yarns. Unless otherwise specified, all fibrous glass yarns used in braiding shall be coated with TFE (polytetrafluoroethylene resin) to the extent of not less than 15 percent by weight of the coated yarn. In addition, after each braid application, the braid shall be coated with TFE. This coating shall be a TFE finisher, TFE extrusion, or TFE unsupported tape.

3.4.2.2 TFE coated fibrous glass tapes. Unless otherwise specified, all fibrous glass tapes used in insulation shall contain not less than 50 percent of TFE by weight of the coated tape.

3.5 Construction. Construction of the wire shall be as specified herein and in the applicable specification sheet.

3.5.1 Conductor construction.

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TABLE I. PHYSICAL PROPERTIES OF INSULATION COMPONENTS.

CHARACTERISTICS	UNSUPPORTED TFE TAPES			EXTRUDED INSULATION OR JACKETS				
	Skived	Cast	Extruded Unskintered	Polytetrafluoroethylene (TFE)	Fluorinated Ethylene Propylene	Ethylene Tetrafluoroethylene (ETFE)	Polyvinylidene Fluoride (PVF2)	Abrasion Resistant (Mineral Filled) Polytetrafluoroethylene (TFE)
Tensile Strength (min average lbs/in <sup>2</sup> )	4000	3000	1300	Size 28-20 4,500 18-12 4,000 10-8 3,500	2000	5000	5000	Size 24-20 4,000 18-4 3,500
Longitudinal elongation (min average percent)	300	300	50	Size 28-14 250 12-8 200	150	150	250	Size 24-8 200 6-4 150
Circumferential elongation (min average percent) $\frac{1}{2}$				Size 28-16 200 14-12 150 10-8 100				Size 24-16 100% 14-12 75% 10-4 50%
Dielectric Strength (minimum average volts/mil)								
0 To 3.5 mills	2700	3200	700					
3.6 To 5.5 mills	2200	2700	700					
5.6 and larger mills	1600							
Specific gravity	2.15 min 2.21 max	2.15 min 2.21 max	1.5 min					

$\frac{1}{2}$  The circumferential elongation test is not applicable for other materials in Table I.

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### 3.5.1.1 Conductor stranding.

3.5.1.1.1 Concentric lay stranding. The conductors of wire sizes 30 through 10 shall be concentric-lay conductors constructed as specified in Table II. Concentric lay shall be interpreted to be a central strand surrounded by one or more layers of helically wound strands. It is optional for the direction of lay of the successive layers to be alternately reversed (true concentric lay) or to be in the same direction (unidirectional lay). The strands shall be assembled in a geometric arrangement of concentric layers, so as to produce a smooth and uniform conductor, circular in cross-section and free of any crossovers, high strands, or other irregularities. The direction of lay of the individual strands in the outer layer of the concentrically stranded conductors of finished wire shall be left hand. The length of lay of the outer layer shall not be less than 8 nor more than 16 times the maximum conductor diameter as specified in the applicable military specification sheet.

3.5.1.1.2 Rope lay stranding. The conductors of wire sizes 8 through 0000 shall be rope-lay, as specified in Table II and in (a) and (b) below.

(a) Rope-lay stranded conductors shall be laid up concentrically with a central member surrounded by one or more layers of helically wound members. It is optional for the direction of lay of successive layers to be alternately reversed (true concentric lay), or to be in the same direction (unidirectional lay). The length of lay of the outer layer of rope-lay stranded members forming the conductor shall not be less than 8 nor more than 14 times the outside diameter of the completed conductor. The direction of lay of the outside layer shall be either left or right hand.

(b) Members of rope-lay stranded conductors: The length of lay of the wires composing the stranded members shall be not greater than 16 times the outside diameter of the member. Stranding of the individual members may be either concentric or bunch.

\* 3.5.1.2 Conductor splices. (For certification of conformity to this requirement, see 4.1.2 and 4.6.2.3.4). Splices in individual strands or members shall be butt brazed. There shall not be more than one strand-splice in any two lay lengths of a stranded concentric lay conductor or in any two lay lengths of any member in a rope lay conductor, except that not more than one splice of an entire member shall be permitted in any two lay lengths of a rope lay conductor. Splices in members of a rope lay construction shall be so finished that the conductor diameter is not increased at the point of brazing. In no case shall the whole conductor be spliced at one point.



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3.5.1.3 Elongation and tensile strength of conductor.

3.5.1.3.1 Soft or annealed copper. The individual strands removed from finished wires with soft or annealed copper conductors, wire sizes 20 and larger, or the whole soft or annealed copper conductor removed from finished wire, sizes 22 and smaller, shall have the following minimum elongation when tested in accordance with 4.6.3.7.1:

Sizes 24 and smaller - 6 percent (minimum).

Sizes 22 and larger - 10 percent (minimum).

There shall be no tensile strength requirements for soft or annealed copper conductors.

3.5.1.3.2 High strength copper alloy. The whole conductor removed from finished wires with high strength copper alloy conductors shall exhibit elongation of 6 percent minimum, and a tensile breaking strength conforming to Table II, when tested in accordance with 4.6.3.8.2.

3.5.1.4 Conductor diameter. The diameter of the conductor shall be as specified in Table II. Applicability of the "general purpose" or of the "small diameter" Table II requirements for maximum conductor diameter shall be as indicated in the specification sheet.

3.5.2 Insulation construction. The insulation shall be constructed as specified in the applicable military specification sheet. All insulation shall be readily removable by conventional wire stripping devices without damage to the conductor.

\* 3.5.2.1 Insulation tape splices. (For certification of conformity to this requirement, see 4.1.2 and 4.6.2.3.4). Splices shall be permitted in the insulation tapes provided the performance characteristics of the finished wire, as defined in this specification, are not affected. However, no splice in one layer of insulation tape shall be so positioned on the wire as to overlap any part of a splice in another layer of insulation tape; also, the measured maximum diameter of the finished wire at a splice in the insulation tape shall not exceed the measured diameter of the finished wire where no tape splice is present by more than five times the nominal thickness of the tape in which the splice occurs (seven times for single-tape insulations). Splices of the outer insulation tape shall not be longer than one inch and not more than one splice of the outer insulation tape shall occur in any 150 feet of the finished wire.

3.5.3 Spark test of primary insulation. When specified in the applicable specification sheet, one hundred percent of the wire shall be subjected to the chain electrode spark test of 4.6.2.3.3 after application of the primary insulation and prior to the application of any other material to the wire.

3.6 Finished wire. The finished wire shall conform to the requirements of Table III and those of the applicable military specification sheet. The requirements of 3.6.1 through 3.6.8, and 3.6.10 also apply.



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TABLE II. DETAILS OF CONDUCTORS.

TABLE II. DETAILS OF CONDUCTORS.											Maximum Resistance of Finished Wire (Ohms/1,000 Ft. at 20°C)						Tensile Breaking Strength Alloy Conductor (Lbs) (Min)			
Size Design- ation	Nominal Conductor Area (Kil Mils) √	Stranding No. of Strands x AWG Gage of Strands	Allowable No. of Missing Strands (Max)	Nominal Dia of Individual Strands (Inch) √	Diameter of Stranded Conductor						Soft or Annealed Copper				High Str Cu Alloy					
					Min (Inch)	General Purpose		Max (Inch)		Small Dia (Alloy)		Nickel Coated	Silver Coated	Nickel Coated	Silver Coated	Tin Coated		Nickel Coated	Silver Coated	
						Silver Coated	Nickel or Tin Coated	Silver Coated	Nickel Coated	Small Dia (Cu)	Small Dia (Alloy)									
30	112	7 x 38	0	0.0040	0.011	0.012	0.013	0.012	0.013	0.012	0.013	0.013	0.012	0.013	100.7	110.7	*108.4	117.4	129.6	5.17
28	175	7 x 36	0	0.0050	0.014	0.015	0.016	0.015	0.016	0.015	0.016	0.016	0.015	0.016	63.8	67.9	68.6	74.4	79.0	8.16
26	304	19 x 38	0	0.0040	0.018	0.020	0.021	0.019	0.020	0.020	0.020	0.020	0.020	0.020	38.4	42.2	41.3	44.8	49.4	
24	475	19 x 36	0	0.0050	0.023	0.025	0.026	0.024	0.024	0.024	0.024	0.024	0.024	0.024	24.3	25.9	26.2	28.4	30.1	
22	754	19 x 34	0	0.0063	0.029	0.032	0.033	0.030	0.031	0.031	0.031	0.031	0.031	0.031	15.1	16.0	16.2	17.5	18.6	
20	1,216	19 x 32	0	0.0080	0.037	0.040	0.041	0.038	0.039	0.039	0.039	0.039	0.039	0.040	9.19	9.77	9.88	10.7	11.4	
18	1,900	19 x 30	0	0.0100	0.046	0.050	0.051	0.048	0.049	0.049	0.049	0.049	0.049	0.050	5.79	6.10	6.23	6.81		
16	2,426	19 x 28	0	0.0113	0.052	0.057	0.058	0.054	0.055	0.055	0.055	0.055	0.055	0.056	4.52	4.76	4.81	5.06		
14	3,831	19 x 26	0	0.0142	0.063	0.072	0.073	0.068	0.069	0.069	0.069	0.069	0.069	0.070	3.06	3.00	3.06	3.06		
+12	6,038	19 x 24	0	0.0179	0.082	0.089	0.090	0.087	0.088	0.088	0.088	0.088	0.088	0.089	1.81	1.89	1.92	2.02		
12	5,874	37 x 28	0	0.0126	0.084	0.089	0.090	0.087	0.088	0.088	0.088	0.088	0.088	0.089	1.90	1.98	2.02	2.02		
10	9,354	37 x 26	0	0.0159	0.106	0.112	0.114	0.110	0.112	0.112	0.112	0.112	0.112	0.113	1.19	1.24	1.26	1.26		
8	16,983	133 x 29	0	0.0113	0.158	0.169	0.173	0.166	0.169	0.169	0.169	0.169	0.169	0.170	0.658	0.694	0.694	0.701		
6	26,818	133 x 27	0	0.0142	0.198	0.213	0.217	0.208	0.212	0.212	0.212	0.212	0.212	0.213	0.264	0.275	0.275	0.280		
4	42,615	133 x 25	0	0.0179	0.250	0.268	0.274	0.268	0.268	0.268	0.268	0.268	0.268	0.269	0.170	0.177	0.183	0.183		
2	66,500	645 x 30	2	0.0100	0.360	0.380	0.390	0.380	0.380	0.380	0.380	0.380	0.380	0.381	0.119	0.144	0.144	0.149		
1	81,700	817 x 30	2	0.0100	0.360	0.380	0.390	0.380	0.380	0.380	0.380	0.380	0.380	0.381	0.108	0.113	0.116	0.118		
0	104,500	1,045 x 30	3	0.0100	*0.395	0.425	0.425	0.425	0.425	0.425	0.425	0.425	0.425	0.425	0.085	0.089	0.091	0.091		
00	133,000	1,330 x 30	3	0.0100	*0.440	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.068	0.071	0.071	0.071		
000	166,500	1,665 x 30	4	0.0100	*0.500	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.054	0.056	0.056	0.056		
0000	210,900	2,109 x 30	5	0.0100	*0.565	0.605	0.605	0.605	0.605	0.605	0.605	0.605	0.605	0.605	0.054	0.056	0.056	0.056		

<sup>1/2</sup> Nominal values are for information only. Nominal values are not requirements.

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TABLE III. REQUIREMENTS OF FINISHED WIRE.

Examination or Test	Requirements	Method
Conductor stranding	Table II and 3.5.1.1	4.6.1
Conductor diameter	Table II and 3.5.1.4	4.6.1
Finished wire diameter	Specification sheet 1/	4.6.1
Construction of insulation	Specification sheet 1/	4.6.1
Removability of insulation	3.5.2	4.6.1
Impulse dielectric test	3.6.2	4.6.3.1
Insulation resistance	Specification sheet 1/	4.6.3.2
Wrap test		
For extruded insulation	3.6.3.1	4.6.3.3.1
For tape or braid insulation	3.6.3.2	4.6.3.3.2
Color	3.6.4	4.6.1
Color striping or banding durability	3.6.4	4.6.3.4
Identification of product	3.6.5	4.6.1
Durability of identification	3.6.5.2	4.6.3.4
Blocking	3.6.6	4.6.3.5
Workmanship	3.6.10	4.6.1
Finished wire weight	Specification sheet 1/	4.6.3.6
Conductor resistance	Table II	4.6.3.7
Elongation and tensile strength of conductor	3.5.1.3	4.6.3.8
Concentricity	70 percent (min) (also 3.6.1)	4.6.3.9
Shrinkage	Specification sheet 1/	4.6.3.10
Wicking	Specification sheet 1/	4.6.3.11
Low temperature (cold bend)	No cracking; no dielectric breakdown	4.6.3.12
Thermal shock resistance	Specification sheet 1/	4.6.3.13
Flammability	After flame, 3 sec (max) Post-flame dielectric - Specification sheet 1/	4.6.3.14 4.6.3.14.3
Life cycle	Specification sheet 1/  No cracking in bend test No dielectric breakdown No pitting	4.6.3.15 4.6.3.15.1 4.6.3.15.2 4.6.3.15.3 4.6.3.15.1
Immersion tests	Diameter increase, 5 percent max No cracking on bending No dielectric breakdown	4.6.3.16 4.6.3.16 4.6.3.16
Humidity resistance	Specification sheet 1/	4.6.3.17
Surface resistance	Specification sheet 1/	4.6.3.18
Smoke test	Specification sheet 1/	4.6.3.19
Acid resistance (when required in the specification sheet)	No dielectric breakdown	4.6.3.20
Continuous lengths	3.6.7	4.6.3.21
* Solderability (tin and silver coated conductors only)	3.6.8	4.6.3.22
* Conductor strand adhesion (when applicable)	3.6.11	4.6.3.23

1/ See appropriate specification sheet.

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3.6.1 Concentricity. The concentricity requirement shall apply to both the primary insulation and the finished wire.

3.6.2 Impulse dielectric test. One hundred percent of the finished wire shall pass the impulse dielectric test of 4.6.3.1, which test shall be made during the final winding of the wire on shipment spools or reels.

3.6.3 Wrap test.

3.6.3.1 For extruded insulation ("wrap back test"). Wire to this specification with insulation composed entirely of extruded material or polyimide-coated extruded material shall show no cracking of the insulation when tested in accordance with 4.6.3.3.1.

3.6.3.2 For tape or braid insulation (mandrel test). Wire to this specification with tapes, braids, or both tapes and braids as components of the insulation shall show no insulation cracking or dielectric breakdown when tested in accordance with 4.6.3.3.2.

\* 3.6.4 Color. The color of the finished wire shall be as indicated by the insulation color designator (see 1.2.1) of the wire part number and the color specified in the procurement contract or order. The first digit of the designator shall indicate the background insulation color and the succeeding digits, if any, shall indicate the colors of the stripes, bands, or tracers. The insulation color designator of the wire shall be listed in MIL-STD-681, System I (differentiation color coding for chassis wiring). The preferred color and any applicable restrictions on available colors are indicated in the individual specification sheet. The color of the background insulation and the colors of any stripes, bands, or tracers shall be in accordance with MIL-STD-104, Class I. The colored stripes or bands, if used, shall be in accordance with MIL-STD-681 and shall be capable of withstanding the durability of color marking test of 4.6.3.4 using the number of strokes and the weight specified in the applicable specification sheet. Durability of color marking test shall not be required on braided tracers if the stripes or bands are under a clear jacket.

\* 3.6.5 Identification of product. Unless otherwise specified in the applicable specification sheet, the finished wire shall be identified by a printed marking applied to the outer surface of the wire. The identification mark shall not be applied by hot stamp marking or other methods which significantly penetrate the insulation.

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The wire part number as specified in the applicable specification sheet, except that inclusion of the color code portion of the part number is not required in the printed marking. At the option of the wire supplier, the color code portion of the part number may be included, but, if included, it shall be included in its entirety, not in part.

The manufacturer's Commercial and Government Entity (CAGE) designation in accordance with Publication H4/H8.

The printing shall be green in color in accordance with MIL-STD-104, Class 1, except that when the wire is any color against which green is difficult to distinguish, the printing shall be white. Identification printing shall be applied with the vertical axes of the printed characters lengthwise of the wire when the nominal diameter of the finished wire is 0.050 inch or smaller. The vertical axes of the printed characters may be either crosswise or lengthwise of the wire when the nominal diameter of the wire exceeds 0.050 inch. All printed characters shall be complete and legible.

3.6.5.1 Additional identification. When specified in the wire procurement contract, the wire shall also be marked in accordance with MIL-W-5088.

3.6.5.2 Durability of identification. Identification of product printing, when applied to the outer surface of the finished wire, shall be capable of withstanding the durability test specified in 4.6.3.4 for the number of cycles and with the weight specified in the applicable specification sheet. This test shall not be required when the identification marking is under a clear jacket.

3.6.6 Blocking. Adjacent turns or layers of the wire shall not stick to one another when tested as specified in 4.6.3.5 at the temperature specified in the applicable specification sheet.

\* 3.6.7 Continuous lengths. The individual continuous lengths of wire in each inspection lot shall be of such footage that, when inspected in accordance with 4.6.3.21 the inspection lot shall conform to the Schedule A continuous length requirements of Table IV or to the Schedule B continuous length requirements of Table V, as applicable. The applicable schedule shall be as specified in the specification sheet. Unless otherwise specified in the contract or order, the footage of the individual continuous lengths in each spool or reel shall be marked on the spool or reel in the sequence in which the lengths will be unwound by the user.

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\* 3.6.8 Solderability. Conductors of finished wires that have tin coated copper strands, silver coated copper strands, or silver coated high strength copper alloy strands shall be tested for solderability as specified in 4.6.3.22. The requirement for acceptable solder coverage of the stranded conductor shall be as defined in MIL-STD-202, Method 208. The test is not applicable to finished wires with nickel coated copper strands or nickel coated high strength alloy strands.

3.6.9 Packaging. Unless otherwise specified in the acquisition contract, the packaging of the wire, when inspected in accordance with 4.7, shall conform to the requirements of Section 5 of this specification.

3.6.10 Workmanship. All details of workmanship shall be in accordance with high grade aircraft wire manufacturing practice. The insulation shall be free of cracks, splits, irregularities, and imbedded foreign material.

3.6.11 Conductor strand adhesion (when applicable). When examined in accordance with 4.6.3.23, 19-strand conductors (wire sizes 26 through 12), taken from finished wire, shall show a total count of at least 13 unbonded single strands, metallic bonded pairs of strands, and metallic bonded groups of strands. For all other conductors the total count of unbonded single strands metallic bonded pairs of strands, and metallic bonded groups of strands shall not be less than 0.70 times the number of strands in the conductor.

TABLE IV. MINIMUM CONTINUOUS WIRE LENGTHS  
(SCHEDULE A REQUIREMENTS).

Wire Size (Range)	Required Minimum Percent of the Total Inspection Lot Footage in Continuous Lengths Greater Than			
	300 feet	100 feet	50 feet	25 feet
30-20	50%	80%	100%	—
18-14	30%	80%	100%	—
12-10	—	50%	80%	100%
8-4	—	20%	50%	100%
2-1	—	—	50%	100%
0-0000	—	—	30%	100%

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TABLE V. MINIMUM CONTINUOUS WIRE LENGTHS  
(SCHEDULE B REQUIREMENTS).

Wire Size (Range)	Required Minimum Percent of the Total Inspection Lot Footage in Continuous Lengths Greater Than				
	500 feet	250 feet	100 feet	50 feet	25 feet
30-6	85%	—	100%	—	—
4-2	—	85%	—	100%	—
1-0000	—	—	85%	—	100%

#### 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 or purchase 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all applicable requirements of Sections 3 and 5. The inspection 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 inspection, as part of manufacturing operations, is an acceptable 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.

\* 4.1.2 Certification of quality. When allowed (see 4.6.2.1, 4.6.2.3.4), certification of quality may be submitted by the contractor. Such certification, however, shall not relieve the contractor from the obligation of meeting with his finished wire, all performance requirements of this specification and applicable specification sheets, including the requirement for which the certification of quality was submitted. The submitting of the certification of quality shall not restrain the Government from exercising the inspection prerogatives reserved under 4.1.

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4.2 Classification of inspections. The inspection requirements under this specification are classified as follows:

- a. Qualification inspections (see 4.4).
- b. Quality conformance inspections (see 4.5).
- c. Inspection of packaging (see 4.7).

4.3 Inspection conditions. Unless otherwise specified in the method, all inspections shall be performed in accordance with the test conditions specified in FED-STD-228.

\* 4.3.1 Test equipment and inspection facilities. Test equipment and inspection facilities shall be of sufficient accuracy, quality and quantity to permit performance of the required inspections. The contractor shall establish calibration of inspection equipment to the satisfaction of the Government. Calibration of the standards which control the accuracy of inspection equipment shall comply with the requirements of MIL-STD-45662.

4.4 Qualification inspections. Qualification inspections in this specification include the initial qualification inspection (4.4.1) and inspection for retention of qualification (4.4.2).

\* 4.4.1 Initial qualification inspection. Initial qualification inspection shall consist of all the tests and examinations of this specification except the examination for continuous lengths and the examination of packaging (see Tables VI, VII and VIII). Performance of the inspection shall be the responsibility of the qualification applicant under authorization of the qualifying activity (see 6.3). The qualification applicant shall furnish a copy of his test results and samples of his product to the qualifying activity for verification tests to be performed at the option of the qualifying activity (see 4.4.1.3).

\* 4.4.1.1 Sampling for initial qualification inspection. Except as provided under qualification by similarity in 4.4.1.2, a finished wire sample of the required length shall be selected for each size range for which qualification is desired in the applicable specification sheet. The sample may be any size wire within the specified size range. Ten linear feet of the coated conductor and fifty linear feet of each tape or yarn (for sizes 8 and larger) used in the manufacture of the finished wire sample shall be included with the wire sample.

<u>Wire size range</u>	<u>Required length of wire sample (feet)</u>
30 through 28	200
26 through 20	200
18 through 14	200
12 through 10	100
8 through 4	100
2 and larger	100



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\* 4.4.1.2 Samples for initial qualification by similarity. Qualification by similarity is applicable where a group of two or more specification sheets covers wires which are identical in materials and construction except that the conductor is different in each specification sheet. In such event, the qualification applicant may select the samples specified in 4.4.1.1 for any size range or ranges of any specification sheet in the similar group. In addition, 10 foot samples of conductor only, applicable to the same wire size range or ranges as the finished wire sample, may be selected for any number of the other specification sheets which differ from the finished sample only in conductor. Approval of the finished wire qualification sample shall also qualify the same wire size range or ranges in each of the other specification sheets for which conductor samples have been tested and approved. Also, where a requirement is more rigorous for a wire being qualified by similarity than for the wire undergoing complete test, the sample undergoing complete test must meet the more rigorous requirement of the similar wire, properties of the conductor excepted, in order to qualify the similar wire; e.g., if the finished wire sample is a 150°C rated wire and the wire being qualified by similarity is rated at 200°C, the finished wire sample must pass the thermal shock test at 200°C in order to qualify the 200°C wire. In the event that required conductor, tape or yarn samples are identical for two or more wires or similarity groups being qualified simultaneously, only one sample of the identical items need be tested. (Note: For purposes of determining identity of construction in specification sheets under the similarity provision, small differences in specified finished wire diameter or weight which are obviously due to differences in the specified conductor shall not be considered as constituting differences in the construction of the wires.)

Similarity Groups

Group 1	M22759/1,/2	Group 6	M22759/14,/15
Group 2	M22759/5,/6	Group 7	M22759/16,/17
Group 3	M22759/7,/8	Group 8	M22759/18,/19
Group 4	M22759/9,/10,/20,/21	Group 9	M22759/28,/29,/30,/31
Group 5	M22759/11,/12,/22,/23	Group 10	M22759/32,/33,/44,/45,/46
		Group 11	M22759/34,/35,/41,/42,/43

\* 4.4.1.3 Qualifying activity samples. A set of untested samples, identical with those specified in 4.4.1.1 and, if applicable, 4.4.1.2, and taken from the same lot or lots as tested by the manufacturer, shall be forwarded, together with the manufacturer's certified test reports, to the qualifying activity (see 6.3), plainly identified by securely attached durable tags marked with the following information:

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Sample for qualification tests  
 WIRE, ELECTRICAL, FLUOROPOLYMER-INSULATED,  
 COPPER OR COPPER ALLOY  
 Specification sheet part number  
 Manufacturer's name and code number (Publication H4/H8)  
 Manufacturer's part number  
 Comprehensive description and prime manufacturer's name and  
 formulation number of the base materials from which the  
 product is made. (This information will not be divulged  
 by the Government)  
 Place and date of manufacture of sample  
 Submitted by (name) (date) for qualification tests in accordance  
 with the requirements of MIL-W-22759E under authorization  
 (reference authorizing letter)

The tags must be stamped by the government Quality Assurance Representative (QAR) inspector as representative samples of the manufacturer's normal production capability. Samples submitted without the stamp will not be accepted.

\* 4.4.2 Retention of qualification. Except as specified in 4.4.2.3, periodic reinspections of product for retention of qualification shall be made at two-year intervals after the date of the letter notifying the manufacturer of his product's initial acceptance for qualification. Materials from current production shall be inspected against the life cycle and surface resistance requirements of Table VII and all the requirements of Tables VIII and VI except the requirements for continuous lengths in Table VI. In every second, such two year inspection period after initial qualification, the remaining tests of Table VII shall also be performed. Except where certification (see 4.4.2.3) has been accepted by the qualifying activity, failure of the manufacturer to submit a retention of qualification test report and, if requested, product samples within 30 days after the end of the 2-year reporting period may result in the removal of the product or products from the Qualified Products List (QPL).

\* 4.4.2.1 Procedure for retention-of-qualification inspection. The qualified manufacturer shall have the responsibility of requesting from the qualifying activity, every two years, authorization to begin the tests for retention of qualification. Unless otherwise specified by the qualifying activity, one wire sample (wire size at the manufacturer's option) from current production shall be tested for each similarity group (see 4.4.1.2). When requested, the manufacturer shall submit a like sample or samples from the same production lot or lots to the qualifying activity. The provision concerning requirements in the similarity group which are more rigorous than those of the wire subjected to complete test shall also be applicable in the retention-of-qualification inspection.

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TABLE VI. QUALITY CONFORMANCE INSPECTION OF FINISHED WIRE.

Examination or Test	Requirements	Method
<u>Group I Characteristics</u>		
Conductor stranding	Table II and 3.5.1.1	4.6.1
Conductor diameter	Table II and 3.5.1.4	4.6.1
Finished wire diameter	Specification sheet 1/	4.6.1
Construction of insulation	Specification sheet 1/	4.6.1
Removability of insulation	3.5.2	4.6.1
Insulation resistance	Specification sheet 1/	4.6.3.2
Color	3.6.4	4.6.1
Color striping or banding durability	3.6.4	4.6.3.4
Identification of product	3.6.5	4.6.1
Durability of identification	3.6.5.2	4.6.3.4
Workmanship	3.6.10	4.6.1
Finished wire weight	Specification sheet 1/	4.6.3.6
Conductor resistance	Table II	4.6.3.7
Conductor elongation and tensile strength	3.5.1.3	4.6.3.8
<u>Group II Characteristics</u>		
* Conductor strand adhesion	3.5.1.1.3	4.6.3.23
Wrap test		4.6.3.3
For extruded insulation	3.6.3.1	4.6.3.3.1
For tape or braid insulation	3.6.3.2	4.6.3.3.2
Concentricity	70 percent (min) (also 3.6.1)	4.6.3.9
Shrinkage	Specification sheet 1/	4.6.3.10
Wicking	Specification sheet 1/	4.6.3.11
* Solderability (tin coated conductors only)	3.6.8	4.6.3.22
Low temperature (cold bend)	No cracking; no dielectric breakdown	4.6.3.12
Thermal shock resistance	Specification sheet 1/	4.6.3.13
* Conductor strand adhesion (when applicable)	3.6.11	4.6.3.23
<u>Group III Characteristics</u>		
Impulse dielectric test	3.6.2	4.6.3.1
<u>Group IV Characteristics</u>		
Continuous lengths	3.6.7	4.6.3.21

1/ See appropriate specification sheet.

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TABLE VII. TESTS APPLICABLE ONLY TO INITIAL QUALIFICATION AND RETENTION OF QUALIFICATION.

Test	Requirement	Method
Blocking	3.6.6	4.6.3.5
Flammability	Table III	4.6.3.14
Life cycle	Table III	4.6.3.15
Immersion tests	Table III	4.6.3.16
Humidity resistance	Specification sheet 1/	4.6.3.17
Surface resistance	Specification sheet 1/	4.6.3.18
Smoke test	Specification sheet 1/	4.6.3.19
Acid resistance (when required in the specification sheet)	No dielectric break-down	4.6.3.20
Solderability (silver coated conductors only)	3.6.8	4.6.3.22

1/ See appropriate specification sheet.

4.4.2.2 Effect of failure in retention-of-qualification inspection. If a failure occurs in the tests for retention of qualification, no wire represented by the sample, nor any other wire manufactured with the same materials and processes, which has not already been submitted for quality conformance inspection, shall be offered for acceptance until the cause for failure has been determined and concurred with by the qualifying activity as not affecting the ability of the wire to meet qualification inspection requirements.

\* 4.4.2.3 Retention of qualification by certification. If production of a qualified wire has not occurred since the previous qualification or retention of qualification submission, qualification may be retained by certification. When production resumes following a certification submission, the manufacturer shall request authorization to perform qualification retention tests. Retention of qualification by certification shall not be permitted for two successive retention of qualification periods.

4.5 Quality conformance inspections. Quality conformance inspections shall include quality conformance process control inspection (4.5.1) and the quality conformance inspection of finished wire (4.5.2).

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4.5.1 Quality conformance process control inspection. This inspection comprises quality conformance tests and examinations of such a nature that they are impossible or impracticable to perform on the finished wire and therefore are conducted at the most appropriate stage of the receiving or the manufacturing operations. The process control tests and examinations are listed in Table VIII. Process control inspection shall be performed on every lot (see 4.5.2.1.1) of wire acquired under this specification.

4.5.1.1 Sampling for quality conformance process control inspection.

\* 4.5.1.1.1 Conductor material. Three ten-foot lengths of conductor, prior to insulation, shall be selected in such manner as to be representative of the material to be used in each inspection lot of finished wire.

TABLE VIII. QUALITY CONFORMANCE PROCESS CONTROL INSPECTION.

Examination of Test	Requirement	Method
Conductor material	3.4.1	4.6.2.1
Insulating material	3.4.2 (Table I)	4.5.1.1.2
Conductor splices	3.5.1.2	4.6.1
Spark test of primary insulation (when specified)	3.5.3	4.6.2.3.3
Circumferential elongation (when specified)	Table I	4.6.2.3.2

4.5.1.1.2 Insulation material. When extruded insulation is used, three samples representative of each inspection lot shall be selected after extrusion. When unsupported tape, coated glass tape, or coated glass yarn is used, three samples representative of each inspection lot shall be selected before application to the wire.

4.5.1.1.3 Splices. The conductor and insulation tape samples of 4.5.1.1.1 and 4.5.1.1.2 shall be subject to examination for conformity of splices, if present. Additionally, the processor's splicing methods may be observed during the insulation process at the discretion of the Government representative. The options of 4.1 are also applicable.

\* 4.5.1.1.4 Spark test of primary insulation. When a spark test of the primary insulation is required (3.5.3), the test sample shall be one hundred percent of the wire after application of the primary insulation and prior to application of any other material. One hundred percent of the wire shall be tested at this stage in production. Portions showing dielectric breakdown under test shall be cut out or removed and testing of the balance of production shall be resumed.

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4.5.1.2 Methods for process control inspection. See Table VIII and 4.6.2.

4.5.1.3 Rejection and retest in process control inspection. When a process control sample selected from a production run fails to meet the specified requirements, no finished wire still on hand or later produced shall be accepted until the extent and cause of the failure have been determined. After investigation, the contractor shall advise the Government of the action taken and, after corrections have been made, shall repeat all the process control tests. Rejection after corrective action will require that the contractor advise the acquiring activity of the details surrounding the retest and cause for rejection.

4.5.2 Quality conformance inspection of finished wire. The quality conformance inspection of finished wire shall consist of the examinations and tests listed in Table VI and described under "Test methods for finished wire" (see 4.6.3). This inspection shall be performed on every lot (see 4.5.2.1.1) of wire acquired under the specification.

4.5.2.1 Sampling for quality conformance inspection of finished wire. MIL-STD-109 shall apply for definitions of inspection terms used herein. For purposes of this specification, the following shall apply.

4.5.2.1.1 Lot. The inspection lot shall include all wire of one part number subjected to inspection at one time.

4.5.2.1.2 Unit of product. The unit of product for determining lot size for sampling shall be one continuous length of wire as offered for inspection.

4.5.2.1.3 Sample unit (Groups I and II tests of Table VI). The sample unit for Groups I and II tests, except for the Group I insulation resistance test (4.6.3.2), shall consist of a single piece of finished wire chosen at random from the inspection lot and of sufficient length to permit all applicable examinations and tests. Unless otherwise specified, the length of the sample unit for Group I tests of Table VI, other than insulation resistance, shall be 20 feet and the length of the sample unit for Group II tests shall be 25 feet. Not more than one sample unit for each group of tests shall be taken from a single unit of product.

4.5.2.1.3.1 Sample unit for insulation resistance test (Group I). The sample unit for the Group I insulation resistance test shall be a specimen at least 26 feet in length selected at random from finished wire which has passed the Group III dielectric test. It is optional whether the specimen is tested on the reel or removed from the reel for the test, provided the length of the specimen can be determined.

4.5.2.1.4 Inspection levels and acceptable quality levels (AQL) (Groups I and II tests). For Group I characteristics, including the insulation resistance test, the inspection level shall be S-2 and the AQL shall be 6.5 percent defective units in accordance with MIL-STD-105. For Group II characteristics, the inspection level shall be S-3 and the AQL shall be 1.5 percent defective units.



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4.5.2.1.5 Sampling and acceptance for the Group III (impulse dielectric test). The sample for the Group III impulse dielectric test shall be 100 percent of the finished wire and every length of the wire shall be subjected fully to the test. Insulation breakdowns resulting from the test and ends or portions not subjected to the test shall be marked or cut out of the finished wire (see 4.6.3.1.3).

4.5.2.1.6 Sampling and acceptability levels for Group IV (continuous lengths) examination. The inspection level and acceptable quality level for this examination shall be as required for the applicable procedure of 4.6.3.13.4.

4.5.2.2 Effect of a quality conformance process control failure on quality conformance testing of finished wire. Quality conformance testing of finished wire may be continued during the investigation of the failure of a process control sample, but there shall be no final acceptance of the finished product until it is determined that the lot meets all the process control requirements of Table VI and the finished wire requirements of Table VIII.

4.5.3 Nonconforming inspection lots. Disposition of inspection lots found unacceptable under quality conformance inspection shall be in accordance with MIL-STD-105.

#### 4.6 Test methods.

4.6.1 General. All samples shall be examined carefully to determine conformance to this specification and to the applicable specification sheets with regard to requirements not covered by specific test methods.

#### 4.6.2 Test methods for process control inspection.

\* 4.6.2.1 Conductor material. Unless otherwise specified in the procurement contract, certification of conformity to the requirements of 3.4.1 shall be acceptable. However, the Government reserves the right, if desired, to confirm the identity of the conductor basic metal and coatings and the thickness of silver or nickel coatings by the methods of standards ASTM B 33, ASTM B 298, ASTM B 355, or ASTM B 624, as applicable, or by other suitable analytical procedures.

4.6.2.2 Insulation material. Samples of insulation material (see 4.4.1.1, 4.5.1.1.2) shall be subjected to the following tests.

##### 4.6.2.2.1 Tensile strength and elongation.

4.6.2.2.1.1 Unsupported tapes. Unsupported tapes shall be subjected to the tensile strength tests and elongation tests of ASTM Standard D882, Method A or B, except that there shall be no limitation as to width of the tape.



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4.6.2.2.1.2 Extruded fluoropolymer primary insulation or jacket. Unless otherwise specified, specimens of extruded fluoropolymer primary insulation or jacket shall be carefully removed from the conductor and tested for tensile strength and elongation in accordance with FED-STD-228, Methods 3021 and 3031 respectively, except that the rate of travel of the power-actuated grip of the tensile machine shall be 10  $\pm$  2 inches per minute for tests of polyvinylidene fluoride specimens. Not applicable to crosslinked constructions.

4.6.2.2.2 Dielectric strength of unsupported tapes. Samples of tape shall be subjected to the short-time test of ASTM Standard D149. Stainless steel electrodes 1/4 inch in diameter and having edges rounded to a 1/32-inch radius shall be used. The radius must be accurate, and should be checked on an optical comparator. Voltage shall be increased at approximately 500 volts per second. Tapes shall be tested with oil as the medium. The oil shall be as specified in MIL-L-23699.

4.6.2.2.3 Specific gravity of unsupported tapes. Samples of tapes shall be subjected to Test Method A of ASTM Standard D792. A suitable wetting agent shall be added to the water to assist in complete wetting of the surfaces of the specimen.

4.6.2.2.2.4 TFE content of coated fibrous glass yarns and tapes. A weighed specimen of the coated fibrous glass shall be ignited for 4 hours in a muffle furnace at 700°C. The residue shall be cooled and weighed and the loss in weight calculated as TFE content of the coated tape or yarn.

4.6.2.3 Circumferential elongation (extruded TFE or abrasion resistant TFE insulation only). This test method measures the elongation of a thin slug of wire insulation in the circumferential (radial) direction. The wire insulation slug is radially elongated by axial movement of a tapered cone through the stationary slug. The overall test apparatus is shown in Figure 1. A 1 to 1-1/2-inch slug of insulation shall be removed from the conductor. Care shall be taken to prevent scratching, crimping, stretching, or otherwise damaging the insulation. The diameter of the exposed conductor should be measured to the nearest 0.001 inch. Cut five test specimens 0.125 inch  $\pm$  .02 inch in length from the insulation slug using a sharp razor blade or an appropriate sample preparation fixture. Both ends of the test specimens shall be cut square. Slide a specimen onto the cone until it just touches the edges of the cone. The cone should be attached to a moveable crosshead as shown in Figure 2. Position the specimen holding block perpendicular to the cone as shown in Figure 3. Align the cone tip and the appropriate sized hole of the specimen holding block for the wire size being tested. Move the cone through the stationary specimen at a uniform speed of 20  $\pm$  .2 inches/minute until the specimen ruptures. Determine the length of the cone that has passed through the specimen causing rupture. The percent circumferential elongation (% CE) is calculated as follows:

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$$\% CE = \frac{(2 \times L \times \tan \Theta - CD)}{CD} \times 100\%$$

L = Cone length required to rupture specimen (inches)

CD = Conductor diameter (inches)

$\Theta$  = Measured cone angle taper (degrees)

$2 \times L \times \tan \Theta$  = Inner diameter of the test specimen at rupture (inches)

Five specimens shall be tested and the average value of the five specimens calculated.

4.6.2.4 Spark test of primary insulation (when specified, 3.5.3). The wire, after application of the primary insulation and prior to the application of any other material, shall be passed through a chain electrode spark test device using the voltage and frequency specified in the applicable specification sheet. The electrode shall be of a suitable bead chain or fine mesh construction that will give intimate metallic contact with practically all the wire insulation surface. Electrode length and speed of wire movement shall be such that the insulation is subjected to the test voltage for a minimum of 0.2 second. Any portion showing insulation breakdown shall be cut out of the wire including at least 2 inches of wire on each side of the failure.

\* 4.6.2.5 Conductor or insulation splices. Unless otherwise specified in the procurement contract, certification of conformity to the splicing requirements of 3.5.1.2 and 3.5.2.1 shall be acceptable. However, the Government reserves the right to inspect any splices in the samples of 4.5.1.1.1 and 4.5.1.1.2 and to observe any splicing performed during insulation of the wire (see 4.5.1.1.3).

4.6.3 Test methods for finished wire. Methods of test of the finished wire shall be as follows.

#### 4.6.3.1 Impulse dielectric test.

4.6.3.1.1 Test equipment. The electrode head through which the wire is passed in the impulse dielectric test shall be of a suitable bead chain construction such that the electrode will give intimate metallic contact with practically all of the wire insulation surface. The characteristics of the test impulse and of the equipment auxiliary to the electrode head shall be as follows:

- (a) Test impulse. The wave form of the voltage supplied to the electrode head shall consist of a negative pulse, the peak magnitude of which shall be as specified in the applicable specification sheet, followed by a damped oscillation. The rise time of the negative impulse wave front from zero magnitude to 90 percent of the specified peak voltage shall be not more than 75 microseconds. The peak value of the first positive overshoot and each of the subsequent damped oscillations shall be smaller than the

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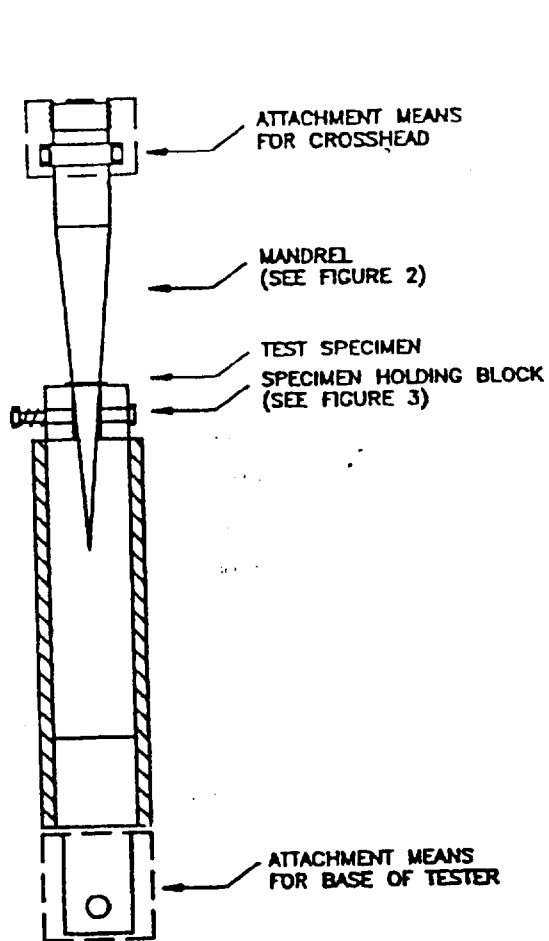


FIG. 1 CIRCUMFERENTIAL ELONGATION APPARATUS

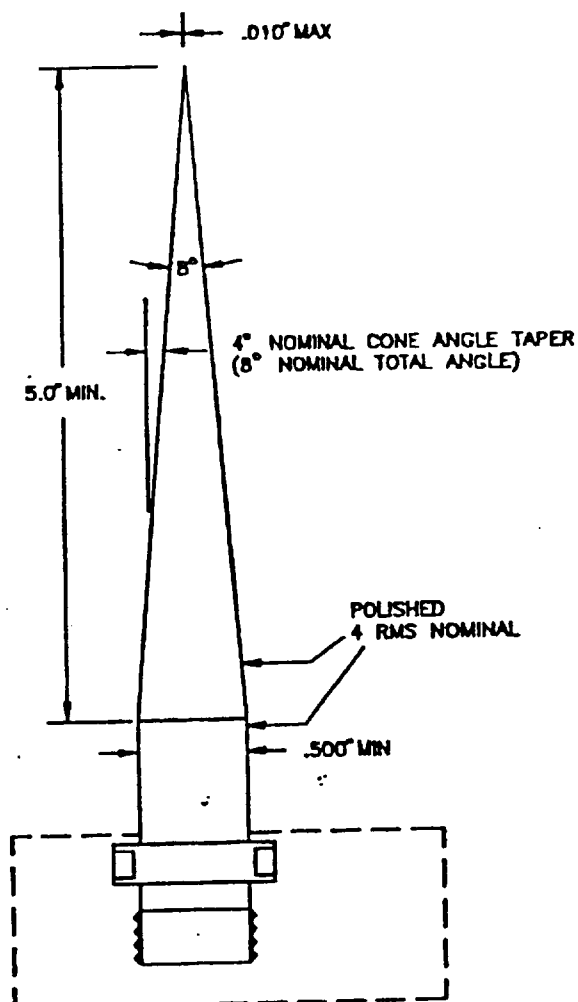


FIG. 2 TEST MANDREL FOR CIRCUMFERENTIAL ELONGATION

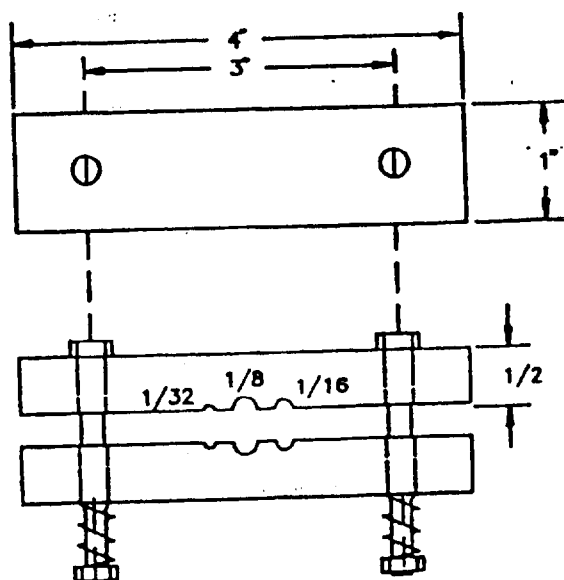


FIG. 3 CIRCUMFERENTIAL ELONGATION SPECIMEN HOLDING BLOCK

## HOLE SIZES

AWG	HOLE SIZE
4-10	1/8
12-16	1/16
18-28	1/32

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initial negative pulse. The time during which each pulse and accompanying damped oscillation (positive and negative) remains at an absolute potential of 80 percent or greater of the specified peak voltage shall be 20 to 100 microseconds. The pulse repetition rate shall be 200 to 250 pulses per second, inclusive. Except for the final peak voltage adjustment (4.6.3.1.3) conformity to these test impulse parameters shall be determined with no capacitive load impressed upon the electrode.

- (b) Capacitive tolerance. The tolerance of the equipment to change in capacitive load shall be such that the peak output voltage shall not be reduced by more than 12 percent in the event of an increase of capacitive load between electrode and ground, from an initial load of 12.5 picofarads per inch to 25 picofarads per inch of electrode length.
- (c) Instrument voltmeter. Connected to the electrode head, there shall be a peak reading voltmeter indicating continually the potential of the electrode. The voltmeter shall show full deflection at a potential not exceeding 15 kilovolts and shall have a minimum accuracy of  $\pm 4$  percent at the specified test impulse potential.
- (d) Failure detection circuit. There shall be a failure detection circuit to give a visible or audible indication of insulation failure, automatically deenergize the electrode head, and stop progress of the wire through the electrode. The detecting circuit shall be sufficiently sensitive to indicate a fault at 75 percent of the specified test voltage when the electrode is arced to ground through a 20 kilohm resistor and shall be capable of detecting a fault which lasts for the duration of only one impulse.

4.6.3.1.2 Calibration of impulse dielectric test equipment. The instrument voltmeter shall be calibrated by comparison with an external standard voltmeter capable of detecting the peak potential at the electrode head with or without auxiliary circuitry. In performing the calibration, the standard voltmeter shall be connected to one of the electrode heads directly or through a calibrated attenuator circuit. The impulse generator shall be energized and the voltage control of the impulse generator shall be adjusted until the reading on the standard voltmeter is the specified potential, at which point the reading on the instrument voltmeter shall be observed and recorded. This calibration shall be repeated for each peak potential at which it is intended to operate the equipment. An alternative procedure is by means of a calibrated oscilloscope connected to the electrode through a suitable attenuator. The peak magnitude of the negative pulse can then be read directly from the waveform display. An oscilloscope connected to the electrode head at suitable test points shall also be used to verify conformance to the other waveform parameters specified in 4.6.3.1.1a.

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4.6.3.1.3 Impulse dielectric test procedure. The finished wire shall be threaded through the electrode head and the conductor shall be grounded at one or both ends. The electrode shall be energized to the specified peak potential and after final adjustment of the voltage with wire in the electrode head, the wire shall be passed from the pay-off spool through the electrode and onto the take-up spool. The speed of passage of the wire through the electrode shall be such that the wire is subjected to not less than 3, nor more than 100 pulses at any given point. Any dielectric failures which occur shall be cut out or marked for later removal along with at least 2 inches of wire on each side of the failure. During all parts of the test, including string-up of new lengths, every effort shall be made to test the entire length, including ends of the wire, in accordance with this procedure. All ends or other portions of the wire not so tested shall be removed subsequent to the test. When specified in contract or order (6.2), dielectric failures, untested portions of wire, or portions which have been exposed to fewer or more than the specified number of pulses may be marked by stripping the insulation or by other suitable method of marking as specified in the contract in lieu of being cut out of the wire.

4.6.3.2 Insulation resistance. The uninsulated ends of a wire specimen at least 26 feet in length shall be connected to a positive DC terminal and the specimen shall be immersed to within 6 inches of its ends in a water bath, at  $25 \pm 5^{\circ}\text{C}$  ( $77 \pm 9^{\circ}\text{F}$ ), containing 0.5 to 1.0 percent of an anionic wetting agent. The specimen shall remain immersed for not less than 4 hours, after which a potential of not less than 250 volts, nor more than 500 volts shall be applied between the conductor and the water bath which serves as the second electrode. The insulation resistance shall be determined after one minute of electrification at this potential, and shall be expressed as megohms-1000 feet by the following calculation:

$$\text{Megohms-1000 feet} = \frac{\text{Total specimen resistance (megohms)} \times \text{immersed length (feet)}}{1000}$$

4.6.3.3 Wrap test.

4.6.3.3.1 For extruded insulation ("wrap back test"). For wire sizes 4 and smaller, a 12-inch specimen plus additional length for winding of finished wire shall be bent back on itself at the mid-portion, on a radius not less than the radius of the wire, and one end of the specimen shall be wound tightly around the other end as a mandrel for four close turns. For sizes 2 and larger, the specimen shall be wound for four close turns around a mandrel of the diameter specified in the specification sheet. In either case, the ends of the specimen shall be left unsecured to permit unhampered relaxation of the turns. The specimen shall then be placed in an air oven for 2 hours at the temperature specified in the specification sheet. At the end of this period, the specimen shall be visually examined, without aid of magnification for cracks.

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4.6.3.3.2 For tape or braid insulation (mandrel test). A specimen of finished wire, with a length of 12 inches plus the additional length required for winding on the mandrel, shall be wound tightly for two close turns around a mandrel of the diameter specified in the applicable specification sheet. The winding shall be in the middle portion of the specimen so that 6 inches of each end shall remain straight. The specimen shall then be removed from the mandrel, examined for cracks visually without aid of magnification, and subjected to the dielectric test of 4.6.3.14.3.

4.6.3.4 Durability of color markings. The durability of product identification or color markings applied to the wire for coding shall be evaluated at 20 to 25°C (68 to 77°F) as follows:

\* 4.6.3.4.1 Durability testing apparatus. The markings durability tester shall be designed to hold a short specimen of finished wire firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. The instrument shall be capable of rubbing a small cylindrical mandrel, which shall be a sewing needle 0.025  $\pm$  0.002 inch in diameter, repeatedly over the upper surface of the wire in such position that the longitudinal axes of the mandrel and the specimen are at right angles to each other with cylindrical surfaces in contact. A weight affixed to a jig above the mandrel shall control the thrust normal to the surface of the insulation. A motor driven reciprocating cam mechanism and counter shall be designed to deliver an accurate number of abrading strokes in a direction parallel to the axis of the specimen. The length of the stroke shall be 3/8 inch and the frequency of the stroke shall be 120 strokes (60 stroking cycles) per minute.

\* 4.6.3.4.2 Durability testing procedure. In performing the test, a specimen of finished wire shall be mounted in the specimen clamp and the jig shall be adjusted to deliver a weight of 500 grams through the abrading mandrel to the markings on the insulation. The specimen shall be subjected to 125 abrasion cycles (250 strokes) of the mandrel and shall then be examined. If there is a continuous line of erasure or obliteration through the stripe, band or printed identification marking, exposing the primary insulation, the specimen shall be considered as having failed. Three specimens shall be tested from each sample unit and failure of any specimen shall constitute failure of the sample unit.

4.6.3.5 Blocking. One end of a piece of finished wire, of sufficient length to perform the test, shall be affixed to a metal spool of the barrel diameter specified for the applicable wire size in Table IX. The wire shall then be wound helically on the spool for at least three turns, with the succeeding turns in close contact with one another. The tension for winding shall be equal to the test load specified for the cold bend test of the same size wire in the applicable specification sheet. The winding shall be continued until there are at least three closely-wound layers of such helical turns on the spool. The free end of the wire shall then be affixed to the spool so as to prevent unwinding or loosening of the turns or layers and the spool and wire shall be placed for 24 hours in an air oven at the temperature



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specified on the applicable specification sheet. At the end of the 24-hour period, the spool and wire shall be removed from the oven and allowed to cool to room temperature. After cooling, the wire shall be unwound manually, meanwhile being examined for evidence of adhesion (blocking) of adjacent turns or layers. (A metal mandrel of diameter equal to the specified spool barrel diameter may be used in lieu of a spool for this test.)

**4.6.3.6 Wire weight.** The weight of each lot of finished wire shall be determined by Procedure I (4.6.3.5.1). Lots failing to meet the wire weight requirement of the applicable specimen sheet when tested in accordance with Procedure I shall be subjected to Procedure II (4.6.3.5.2). All reels or spools failing to meet the requirements of the applicable specification sheet shall be rejected. The sampling plans of 4.5.2.1 are not applicable in Procedure II.

**4.6.3.6.1 Procedure I.** The length and weight of a specimen at least 10 feet long shall be accurately measured and the resultant measurements converted to pounds per 1000 feet.

**4.6.3.6.2 Procedure II.** The net weight of the finished wire on each reel or spool shall be obtained by subtracting the tare weight of the reel or spool from the gross weight of the reel or spool and the wire thereon. The net weight of the wire on each reel or spool shall be divided by the exactly determined length of wire on that reel or spool and the resultant figure converted to pounds per 1000 feet. When wood or other moisture absorbent materials are used for reel or spool construction, gross and tare weight determinations shall be made under substantially the same conditions of relative humidity.

**4.6.3.7 Conductor resistance.** The DC resistance of the conductor shall be measured in accordance with Method 6021 of FED-STD-228 except that the wire shall be tested dry without immersion.

**4.6.3.8 Conductor elongation and tensile strength.**

\* **4.6.3.8.1 Soft or annealed copper.** Elongation tests of soft or annealed copper conductors shall be performed in accordance with Method 3211 of FED-STD-228, except that the elongation at break of the individual strand or of the first strand of the whole conductor, as applicable, shall be determined by means of a recording chart on the testing machine rather than by measuring the specimen after the break. For wire sizes 20 and larger, the tests shall be performed upon individual strands taken from the conductor of the finished wire. For sizes 22 and smaller, the tests shall be performed upon the whole conductor removed from the finished wire and the elongation shall be measured when the first strand of the conductor breaks. For wire sizes 20 and larger, only the values obtained with individual strands shall be considered and, for wire sizes 22 and smaller, only the values obtained with the whole conductor shall be considered in determining the conformance of soft or annealed copper conductors to elongation requirements of this specification.



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\* 4.6.3.8.2 High strength copper alloy. Elongation and tensile strength tests of high strength alloy conductors shall be performed in accordance with Method 3211 of FED-STD-228 except that the tensile strength shall be reported as the tensile breaking strength of the conductor rather than in pounds per square inch; also, the elongation at break of the first strand of the whole conductor shall be determined by means of a recording chart on the testing machine rather than by measuring the conductor specimen after the first strand breaks. The tests shall be performed upon the whole conductor removed from the finished wire. Conductor elongation shall be measured when the first strand of the conductor breaks, and the total tensile force indicated by the testing machine at break of that strand shall be regarded as the breaking strength of the conductor. Only the values thus obtained with the whole conductor shall be considered in determining the conformity of high strength alloy conductors to the elongation and tensile strength requirements of this specification.

4.6.3.9 Concentricity. The concentricity of the primary insulation and of the finished wire shall be determined in accordance with the procedures of 4.6.3.8.1 and 4.6.3.8.2 as applicable. All wall thickness measurements shall be made on cross sections of the wire under suitable magnification. A wall thickness shall be the shortest distance between the outer rim of the primary insulation or finished wire, as applicable, and the outer rim of the outermost strand of the conductor.

4.6.3.9.1 Concentric-lay wires. The concentricity of the primary insulation or of the finished wire shall be determined by first locating and recording the minimum wall thickness measured on a cross section of the primary insulation or finished wire. The maximum wall thickness of this same cross section of the primary insulation or finished wire shall also be located and recorded. For concentric-lay wires, 100 times the ratio of the minimum wall thickness to the maximum wall thickness shall define the percent concentricity.

4.6.3.9.2 Rope-lay wires. The concentricity of the primary insulation or of the finished wire shall be determined by first locating and recording the minimum wall thickness measured on a cross section of the primary insulation or of the finished wire. From this point on the outer rim of the primary insulation or finished wire at which the minimum wall thickness was measured, three more reference points 90 degrees apart on the outside rim of the primary insulation or finished wire shall be established. At each of the three reference points the nearest member of the rope-lay conductor shall be selected and the minimum wall thickness between that member and the outer rim of the primary insulation or finished wire shall be measured. The average of the four readings shall be considered to be the average wall thickness. For rope-lay wires, 100 times the ratio of the minimum wall thickness to the average wall thickness shall define the percent concentricity.

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\* 4.6.3.10 Shrinkage. One inch of insulation shall be stripped from each end of a 14-inch specimen of finished wire, using a razor blade or equivalent held perpendicular to the axis of the wire for the insulation-removal operation. The length of exposed conductor at each end of the specimen shall be determined to the nearest 0.01 inch. The specimen shall be exposed to the temperature specified in the applicable specification sheet for 6 hours in an air oven. At the end of this period, the specimen shall be removed from the oven and allowed to return to room temperature. The shrinkage of the insulation shall then be measured as the greatest additional distance which any layer of the insulation, including jacket if present, has receded from either end of the conductor; that is, the measurement obtained at the end showing the greater shrinkage shall be considered the shrinkage of the specimen. One specimen shall be tested from each sample unit.

4.6.3.11. Wicking. Wicking shall be determined by Procedure I or II as specified in the applicable specification sheet.

4.6.3.11.1 Procedure I. The wire specimen shall be 4  $\pm$  1/16 inches in length, with square-cut ends, and shall be weighed accurately to the nearest 0.1 milligram. The weighed specimen shall be placed upright with the lower 2 inches of its length immersed in distilled water in an open container and shall be conditioned thus for 24 hours at room temperature in a draft-free area. It shall then be removed from the distilled water, the surface of the insulation shall be wiped free of excess moisture with a clean, dry, lint free cloth, and, within 5 minutes after removal from the water, the specimen shall be weighed again to the nearest 0.1 milligram. Change in weight shall be calculated to percent of the original specimen weight.

4.6.3.11.2 Procedure II. The specimen and the procedure shall be identical with Procedure I except that standard dye solution (4.6.3.11.3) shall be substituted for the distilled water of Procedure I. In addition, immediately after the final weighing, the specimen shall be observed under ultraviolet light to determine, to the nearest 0.05 inch, the distance the dye solution has traveled in any part of the insulation by wicking action. The layers of insulation may be dissected away with a sharp blade, working from the upper end of the specimen, to facilitate observation.

4.6.3.11.3 Standard dye solution. The dye solution shall be prepared as follows:

Ethyl alcohol	30 ml
Rhodamine B dye	0.02 gm
Aerosol OT (.75% solution)	3 ml
Distilled water to make	2 liters

The dye shall be dissolved in the ethyl alcohol before adding to the water. The solution shall be kept stoppered and a fresh solution shall be prepared every 30 days. A new portion of the solution shall be used for each test conducted.

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\* 4.6.3.12 Low temperature (cold bend). One end of a wire specimen 36 inches in length shall be secured to a rotatable mandrel in a cold chamber and the other end to the load weight specified in the applicable specification sheet. The diameter of the mandrel shall be as specified in the specification sheet. Provision shall be made for rotating the mandrel by means of a handle or control located outside the chamber. The specimen of wire and the mandrel shall be conditioned for 4 hours at the temperature specified in the applicable specification sheet. At the end of this period and while both mandrel and specimen are still at this low temperature, the specimen shall be wrapped helically for its entire length or for 20 turns, whichever is the lesser number of turns around the mandrel without opening the chamber. The bending shall be accomplished at a uniform rate of  $2 \pm 1$  RPM. At the completion of this test the specimen shall be removed from the cold box and from the mandrel without straightening. The specimen shall be examined without magnification for cracks in the insulation. The insulation shall then be removed for a distance of 1 inch from each end of the specimen and the specimen shall be subjected to the dielectric test specified in 4.6.3.15.3 with the bent portion submerged.

#### 4.6.3.13 Thermal shock resistance.

4.6.3.13.1 Preparation of specimen. A specimen of wire five feet long shall be prepared by carefully removing 1 inch of insulation from each end of the wire. (For purposes of this test, insulation is defined as all layers of non-conducting material covering the electrical conductor, e.g., primary insulation, all tapes and braids, and the jacket.) A razor blade or equivalent, held perpendicular to the axis of the wire, shall be used to cut the insulation for the removal operation. The length of exposed conductor at each end of the specimen shall be measured to the nearest 0.01 inch. The specimen shall be formed into a loose coil not less than 1 foot in diameter and shall be laid on a wire screen for handling throughout the test.

4.6.3.13.2 Test procedure. The specimen shall be placed for 30 minutes in a preheated air circulating oven at the temperature specified in the applicable specification sheet. The specimen shall then be removed from the oven and, within two minutes, placed in a chamber which has been precooled to  $-55 \pm 2^{\circ}\text{C}$  ( $-67 \pm 3.6^{\circ}\text{F}$ ). It shall be exposed to this temperature for 30 minutes, after which it shall be removed and allowed a minimum of 30 minutes to return to room temperature, 20 to  $25^{\circ}\text{C}$  ( $68$  to  $77^{\circ}\text{F}$ ). At the conclusion of this cycle, the distance from the end of each layer of insulation to the end of the conductor shall be measured to the nearest 0.01 inch. This thermal shock cycle and the measurements shall be repeated for an additional three cycles (a total of four cycles). Any measurement varying from the original measurement by more than the amount specified in the applicable specification sheet shall constitute failure. Any flaring of any layer shall also constitute failure.

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4.6.3.14 Flammability.

4.6.3.14.1 Apparatus. The flammability test chamber shall be approximately one foot square by two feet in height, and shall be open at top and front to provide adequate ventilation for combustion but prevent drafts. Means shall be provided in the chamber to hold the test specimen taut at an angle of 60 degrees from horizontal in a vertical plane parallel to and about 6 inches in front of the rear wall of the chamber. The test burner shall be a Bunsen type gas burner having a 1/4 inch inlet, a needle valve in the base for gas adjustment, a bore of 3/8 inch nominal, and a length of approximately 4 inches above the air inlets. The burner shall be fitted with a wing top flame spreader having a 1/16 inch by 2 inch opening.

4.6.3.14.2 Procedure. A 24-inch specimen of wire, marked at a distance of 8 inches from the lower end to indicate the point of contact for the test flame, shall be clamped tautly, at 60 degrees from horizontal, in the specimen holder of the test chamber. The burner shall be adjusted to deliver an all-blue flame, 2 inches high, at a temperature of  $955 \pm 30^{\circ}\text{C}$  ( $1751 \pm 54^{\circ}\text{F}$ ), as measured with a thermocouple pyrometer. With the burner held at a 90 degree angle to the wire specimen and the long dimension of the flame spreader parallel to the axis of the specimen, the hot tip of the flame shall be applied to the wire so that the midpoint of the flame touches the 8-inch mark on the specimen. The period of flame application shall be 15 seconds for wire sizes 30 through 18, 30 seconds for sizes 16 through 12, 1 minute for sizes 10 through 4, and 2 minutes for larger sizes. At the close of the application period, the flame shall be withdrawn and the duration of the after flame in the specimen shall be noted. When required by the applicable specification sheet, the burned section of the wire specimen shall be subjected to the post-flame dielectric test of 4.6.3.14.3 are met. Breaking of the wire specimens in sizes 24 and smaller shall not be considered as failure provided the requirement for flame travel limits, when specified in the applicable specification sheet, and duration of flame requirement are met.

4.6.3.14.3 Post-flame dielectric test. When a post-flame dielectric test is required, the specimen from the flame test shall be clamped firmly in a horizontal position, leaving the burned portion of the wire accessible to a contact plate jig equal to that shown in Figure 4. The bottom contact plate shall be placed underneath the wire and shall make contact with the center 1/2-inch area of the burned section of the wire on the side of the insulation which has been nearest the flame. The upper contact plate shall be placed on top of the specimen, directly over the bottom plate, and a 1/4-pound weight shall be placed on the upper plate, directly over the specimen, to insure contact with the burned area. The voltage specified in the applicable specification sheet shall then be applied between the conductor of the specimen and the contact plates of the jig. The voltage shall be gradually increased at a uniform rate from zero to the specified voltage in 1/2 minute, maintained at that voltage for 1 minute and gradually reduced to zero in 1/2 minute. There shall be no dielectric failure of the specimen under this test.

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#### 4.6.3.15 Life cycle.

4.6.3.15.1 Air oven. One inch of the insulation shall be removed from each end of a 24-inch specimen of finished wire. The central portion of the specimen shall then be bent over a horizontally placed mandrel of the diameter specified in the applicable specification sheet. Each end of the conductor shall be loaded with the weight specified in the specification sheet, so that the portion of the insulation between the conductor and mandrel is under compression and the conductor is under tension. This specimen, so prepared on the mandrel shall be placed in an air-circulating oven and maintained for a period of 120 hours or the length of time specified in the specification sheets, at the temperature specified in the specification sheet. After completion of the air oven test, the specimen shall be cooled to between 20 and 25°C (68 to 77°F), within a period of 1 hour. When cooled, the wire shall be freed from tension, removed from the mandrel, and straightened. The specimen shall be examined for color retention (3.6.4). The specimen shall then be subjected to the bend test (4.6.3.14.2) followed by dielectric test (4.6.3.14.3). After the dielectric test, the insulation shall be removed from the specimen and the conductor shall be examined for pitting.

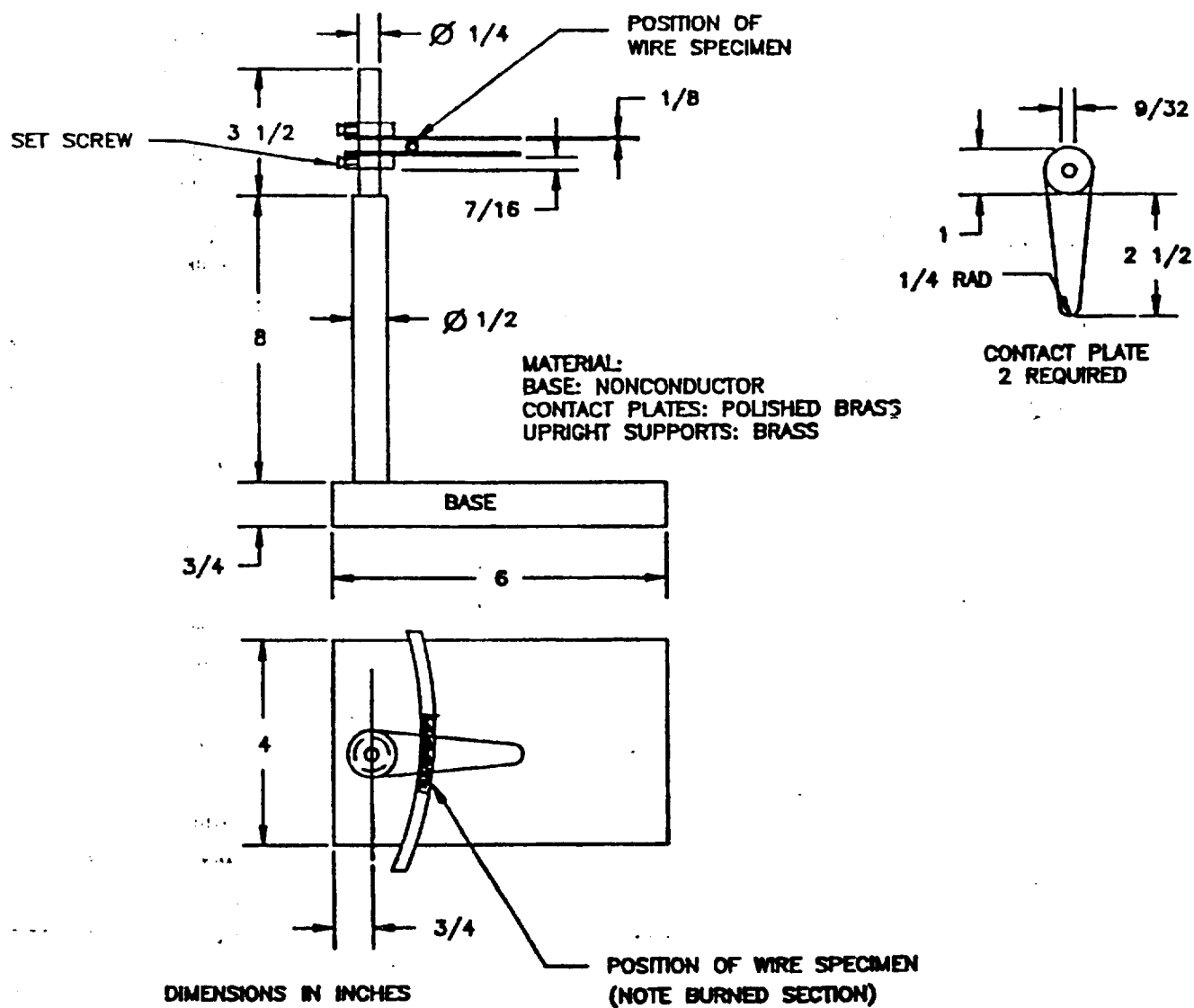
4.6.3.15.2 Bend test. In a temperature maintained between 20 and 25°C (68 to 77°F), one end of the specimen shall be secured to the mandrel and the other end to the load weight specified in the applicable specification sheet. The mandrel shall be rotated until the full length of the specimen is wrapped around the mandrel and is under the specified tension with adjoining coils in contact. The mandrel shall then be rotated in reverse direction until the full length of the wire which was outside during the first wrapping is now next to the mandrel. This procedure shall be repeated until two bends in each direction have been formed in the same section of the wire. The outer surface of the wire shall then be observed for cracking of the insulation.

4.6.3.15.3 Dielectric test. The uninsulated ends of the specimen shall be attached to an electric lead. The specimen shall be immersed in a 5 percent, by weight, solution of sodium chloride in water at 20 to 25°C (68 to 77°F), except that the uninsulated end and 1-1/2 inches of insulated wire at each end of the specimen shall protrude above the surface of the solution. After immersion for 5 hours, the voltage specified in the applicable specification sheet at 60 hertz (cycles per second) shall be applied between the conductor and an electrode in contact with the liquid. This voltage shall be gradually increased at a uniform rate from zero to the specified voltage in 1/2 minute, maintained at that voltage for a period of 5 minutes, and gradually reduced to zero in 1/2 minute.

4.6.3.16 Immersion tests. Specimens of wire of sufficient length to perform the subsequent tests shall be gaged to determine their initial diameter and shall then be immersed to within 6 inches of their ends in each of the following fluids (using a separate specimen for each fluid) for 20 hours at a temperature of 48 to 50°C (118.4 to 122°F for fluids (a) and (b) and at -20 ± 2°C (68 ± 3.6°F) for fluids (c) and (d).

- (a) Lubricating oil, aircraft, turbine engine, synthetic base, MIL-L-23699.

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FIGURE 4. CONTACT PLATE JIG FOR POST-FLAME DIELECTRIC TEST.



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- (b) Hydraulic fluid, petroleum base, aircraft missile, and ordnance, MIL-H-5606.
- (c) Isopropyl alcohol, TT-I-735.
- (d) Turbine fuel, aviation, Grade JP-4, MIL-T-5624.

During the immersion tests, the radius of bend of the wire shall be not less than fourteen times the specified maximum diameter of the wire under test. Upon removal from the liquids, the specimen shall remain for 1 hour in free air at room temperature. The diameter shall be gaged and compared to the initial diameter. The insulation, braid, and protective coating shall be removed for a distance of 1/2 inch from each end of a 24-inch length of the specimen and this length shall be subjected to the bend test of 4.6.3.14.2 followed by the dielectric test of 4.6.3.14.3.

4.6.3.17 Humidity resistance. A 52-foot specimen of wire shall be subjected to the following:

4.6.3.17.1 Apparatus. The apparatus shall consist of a test chamber capable of maintaining an internal temperature of  $70 \pm 2^{\circ}\text{C}$  ( $158 \pm 3.6^{\circ}\text{F}$ ) and an internal relative humidity of  $95 \pm 5$  percent. The test chamber shall be capable of being so sealed as to retain the total moisture content in the test space. The heat loss from the chamber shall be sufficient to reduce the internal temperature from the above specified operating temperature to not more than  $38^{\circ}\text{C}$  ( $100.4^{\circ}\text{F}$ ) within a period of 16 hours from the time of removal of the source of heat. Distilled or demineralized water shall be used to obtain the required humidity.

4.6.3.17.2 Procedure. The specimen shall be placed in the test chamber and the temperature and relative humidity raised over a 2-hour period to the values specified in 4.6.3.16.1 and maintained at such for a period of 6 hours. At the end of the 6-hour period the heat shall be shut off. During the following 16-hour period, the temperature must drop to  $38^{\circ}\text{C}$  ( $100.4^{\circ}\text{F}$ ) or lower. At the end of the 16-hour period, heat shall be again supplied for a 2-hour period to stabilize at  $70 \pm 2^{\circ}\text{C}$  ( $158 \pm 3.6^{\circ}\text{F}$ ). This cycle (2 hours heating, 6 hours at high temperature, 16 hours cooling) shall be repeated a sufficient number of times to extend the total time of the test to 360 hours (fifteen cycles). At the end of the fifteenth cycle, the 50-foot center section of the specimen shall be immersed in a 5 percent, by weight, solution of sodium chloride in water at room temperature. The insulation resistance of the specimen shall be measured with the outer surface of the specimen grounded, through an electrode in the electrolyte, and with a potential of 250 to 500 volts DC applied to the conductor of the specimen after 1 minute of electrification at this potential. The insulation resistance shall be converted to megohms for 1000 feet by the calculation shown in 4.6.3.2.



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4.6.3.18 Surface resistance. The surface resistance of the finished wire shall be measured in accordance with Method 6041 of FED-STD-228. All specimens, after having been provided with the required electrodes but prior to testing, shall be cleaned by the procedure described in the test method. In positioning the specimens in the test chamber, the specimens shall be so placed that their ends are a minimum of one inch from any wall of the chamber.

4.6.3.19 Smoke. This test shall be conducted in still air at an ambient temperature of  $25 \pm 5^{\circ}\text{C}$  ( $77 \pm 9^{\circ}\text{F}$ ). A specimen approximately 15 feet long of the wire shall be so suspended that at least the central 10-foot section is horizontal and unsupported. One end of the wire shall be suitably weighted in order that no sagging will occur throughout the test. An electric current shall be applied to the wire, and the voltage drop measured over the central 10-foot portion. From the current and voltage values, the resistance of the wire shall be calculated. The temperature of the wire conductor shall be determined from the change in resistance. The current shall be so adjusted that the conductor temperature stabilizes at the temperature specified in the applicable specification sheet. This conductor temperature shall be thus maintained for 15 minutes during which time there shall be no indication of visible smoke. A flat-black background shall be used for this test.

4.6.3.20 Acid resistance. When acid resistance is specified in the specification sheet, specimens of finished wire, 24 inches long, shall have 1/2 inch of insulation removed at each end. The specimens shall then be immersed to within 1-1/2 inches of each end in red fuming nitric acid (specific gravity, 1.52) at normal room temperature for 8 hours. Following this immersion in acid, the specimens shall be removed and immersed, except for 1-1/2 inches at each end, for 1 hour in water at room temperature containing 0.5 percent of aerosol or equivalent wetting agent. The specimens in the water solution shall then be subjected to the dielectric test of 4.6.3.14.3.

\* 4.6.3.21 Continuous lengths. Unless otherwise specified in the ordering data (6.2), the inspection requirements for continuous wire lengths shall be satisfied by the supplier's certificate of conformity and the presence of the required piece length markings on the spools or reels (3.6.7). However, the Government reserves the right to examine such certified lots if deemed necessary to assure that the lengths actually conform to requirement. When the ordering data specifies examination of the wire lengths, the Government representative shall examine the wire at his own discretion to determine conformity in this characteristic. In measuring continuous wire lengths where the wire has been marked or stripped of insulation in lieu of being cut to mark insulation failures or identify untested or improperly tested areas (4.6.3.1.3), such marking or stripping shall be considered equivalent to complete severance of the wire at the two ends of each marked or stripped area.

\* 4.6.3.22 Solderability. Unless otherwise specified, five specimens, AWG 10 and smaller, shall be prepared and tested for solderability using Method 208 of MIL-STD-202. The specimens shall be tested without steam aging using a type R flux.

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\* 4.6.3.23 Conductor strand adhesion (when required by the specification sheet).

\* 4.6.3.23.1 Procedure for 19-strand conductor (wire sizes 26 through 12). The specimen shall be a 6-inch length of the finished wire. With an insulation-stripping tool, a stripping action shall be initiated two inches from one end of the specimen. Without kinking or otherwise damaging the conductor, the insulation slug shall be moved lengthwise until approximately 3/4 inch of the conductor is exposed. The specimen shall be removed from the stripping tool and examined in accordance with 4.6.3.23.1.1 for unidirectional lay conductor or 4.6.3.23.1.2 for true concentric lay conductor (see 3.5.1.1.1), as applicable.

\* 4.6.3.23.1.1 Unidirectional lay. Grip the insulation with the fingers at both ends of the exposed portion of the conductor and rotate one end of the specimen so as to untwist the exposed strands and make them parallel with the conductor axis. (The use of rubber pads or similar holding aids is permitted.) Retaining the grip position used to untwist the strands, push the exposed ends toward each other in the conductor axis, causing the strands to spread apart in a "bird cage" effect. Gently probe unseparated strands with a fine needle or thin blade to determine whether they are adhered together by a metallic bonding or simply lying side-by-side. Metallic bonded pairs or groups of strands which cannot be separated along the whole "bird cage" length without forcing the needle or blade between the strands shall each be counted as one. The total number of unbonded single strands plus the number of metallic bonded pairs and metallic bonded groups of strands in the specimen shall be not less than 13 (see 3.6.11). One specimen shall be examined from each sample unit.

\* 4.6.3.23.1.2 True concentric lay. Grip the specimen as described in 4.6.3.23.1.1, but rotate the exposed portion only enough to untwist the 12-strand outer layer of the conductor. Push the ends of the exposed portion together to "bird cage" this outer layer and determine with needle or blade, as in 4.6.3.23.1.1, the number of unbonded single strands, metallic bonded pairs of strands, and metallic bonded groups of strands. Using a suitable tool, snip through each unbonded single strand and each bonded pair or group of strands of the outer layer approximately in the center of the "bird cage" and fold the snipped ends back toward the respective ends of the specimen. (Do not cut the 7-strand core of the conductor.) Now determine the count of unbonded single strands, metallic bonded pairs, and metallic bonded groups in the 7-strand core, using the procedure of 4.6.3.23.1.1. The total count for the 12-strand outer layer plus the 7-strand core shall be not less than 13 (see 3.6.11). One specimen shall be examined from each sample unit.

\* 4.6.3.23.2 Procedure for conductors with other than 19 strands (wire sizes 10 and larger). Modifying the procedures of 4.6.3.23.1 through 4.6.3.23.1.2 as necessary, the total count of unbonded groups of strands in the conductor shall be determined. One specimen shall be examined from each sample unit.

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4.7 Inspection of packaging. The packaging of materials ready for shipment shall be examined to determine conformity to the requirements of Section 5.

## 5. PACKAGING

5.1 Preservation and unit packaging. Preservation and unit packaging shall be Level A or Level C. Unless otherwise specified in the contract or order (6.2), Level A shall be applicable.

5.1.1 Level A. Shall be in accordance with the Level A preservation, unit pack, requirements of MIL-C-12000 and as follows:

\* 5.1.1.1 Reels and spools. Wire shall be delivered wound on reels and spools of a nonreturnable type. Each reel or spool shall have an appropriate diameter for the respective wire size. In no case shall the barrel of the reel or spool have a diameter less than that specified in Table IX or less than 3 inches, whichever is greater. Reels and spools shall be suitably finished to prevent corrosion under typical storage and handling conditions. The method of attachment of flanges to barrels on metal reels shall be structurally equivalent to a full circumferential crimp.

TABLE IX. BARREL DIAMETERS OF SPOOLS AND REELS.

Wire Size	Minimum Diameter of Barrel (as Times Minimum Diameter of Finished Wire, Except see 5.1.1.1)
30-14	50X
12-10	40X
8-1	30X
0-0000	20X

5.1.1.2 Winding requirements. Unless otherwise specified in the ordering data (6.2), there shall be no restriction on the number of wire lengths per reel or spool, provided the wire length requirements of 3.6.7 and Table IV are met by the inspection lot.

5.1.2 Level C. Level C preservation and unit packaging shall be in accordance with the MIL-C-12000 Level C requirements for preservation unit pack.

5.2 Packing. Packing shall be Level A, B or C in accordance with MIL-C-12000. Unless otherwise specified in the order (6.2), Level C shall be applicable.

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5.3 Marking. Unless otherwise specified in the contract or order, each reel or spool shall be marked with the footage of the individual continuous lengths wound thereon, as specified in 3.6.7. In addition, interior packages and exterior shipping containers shall be marked in accordance with MIL-C-12000 and MIL-STD-129. The identification shall be composed of the following information listed in the order shown:

\* WIRE, ELECTRICAL, FLUOROPOLYMER-INSULATED, COPPER \*

Specification sheet part number

Example: MIL-W-22759/X-XXXX

Specification MIL-W-22759

Length \_\_\_\_\_ feet

Size

Date of manufacture

Name of manufacturer

\* OR "COPPER ALLOY", as applicable

## 6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The electric wires covered by this specification are intended for use in any application where their performance characteristics are required. The wires are suitable for installation on aerospace electrical systems within the limitations of applicable performance requirements.

6.1.1 Temperature rating. Temperature ratings as specified in specification sheets pertaining to this specification represent the maximum permissible operating temperature of the conductor. The maximum ambient temperature should be the rated maximum conductor temperature of the wire diminished by the operating rise in temperature of the conductor.

6.1.2 Size designations. The conductor sizes and the corresponding wire size designations of this specification are in accordance with established usage for stranded copper conductors for hookup wire in the electronic and aircraft industries (see ASTM Standard ASTM B 286, Copper Conductors for Use in Hookup Wire for Electronic Equipment). It should be noted that these sizes and size designations are not identical with American Wire Gage (AWG) sizes for solid wire and strands. The diameters and cross-sectional areas of the stranded conductors of this specification are, in most sizes, only roughly approximate to those of AWG solid conductors of the same numerical size designation.

## 6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

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- a. Title, number and date of this specification.
- b. Applicable specification sheet number, title and date.
- c. Applicable specification sheet part number (see 1.2.1).
- d. Color required (see 3.6.4).
- e. Quantity of wire required.
- f. Levels of packaging and packing required.
- g. Exceptions, if any, to the optional provisions of this specification including:
  - (1) Responsibility for inspection, if other than specified in 4.1.
  - (2) Statement, if applicable, that certification of conformity (see 4.6.2.1, 4.6.2.3.4 and 4.6.3.20) will not be accepted. Statement should include testing schedule to be substituted.
  - (3) Marking of dielectric test failures or irregularities by stripping of insulation or by other method specified in the contract in lieu of cutting of the wire, if applicable (see 4.6.3.1.3).
  - (4) Special preparation for delivery requirements, if applicable (see Section 5).

6.3 Qualification. 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 the applicable Qualified Products List (QPL) 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. For all MIL-W-22759 specification sheets identified on the last page of the documents as prepared by the Naval Air Systems Command (AS), the activity responsible for Qualified Products Listing (the "qualifying activity") is the Naval Air Systems Command, Washington, DC 20361-5110. (For the specification sheets similarly identified as prepared by Air Force-85, the activity responsible for Qualified Products Listing is the Air Force Logistics Command, Electronic Support Division, 2750 ABM/ES, Gentile Air Force Station, Dayton, OH 45444-4500). However, application for qualification of products for all specification sheets should be made to the Naval Avionics Center (Code 444), 6000 East 21st Street, Indianapolis, IN 46219-2189, who has been designated agent for establishing the Qualified Products List.

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6.4 Conformity to qualified sample. It is understood that wire supplied under contract should be identical in every respect to the qualification sample tested and found satisfactory, except for changes previously approved by the Government. Any unapproved changes from the qualification sample shall constitute cause for rejection.

6.5 International standardization. Certain provisions of this specification are the subject of international standardization agreements (ASOC Air Std. 12/5, and STANAG 3317). When amendment, revision, or cancellation of this specification is proposed which will affect or violate the international agreements concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

6.6 Subject term (key word) listing.

Aerospace wire electrical  
 Finished wire  
 Conductor material  
 Insulating material  
 Stranding  
     a) Concentric lay stranding  
     b) Rope lay stranding

6.7 Marginal notations. The margins of this specification are marked with an asterisk to indicate where significant changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content as written irrespective of marginal notations and relationship to the last previous issue.

Custodians:

Army - CR  
 Navy - AS  
 Air Force - 85  
 NASA - NA

Preparing activity:

Navy - AS

Agent:

DLA - IS

Review activities:

Army - AR, ME, MI  
 Navy - EC, OS  
 Air Force - 80  
 DLA - IS

(Project 6145-1152)

User activities:

Army - AT, AV  
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Review/user information is current as of the date of this document. For future coordination of changes in this document, draft circulation should be based on the information in the current Federal Supply Classification Listing of DOD Standardization Documents.



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### I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER  
MIL-W-22759E

2. DOCUMENT DATE (YYMMDD)  
90.12.31

3. DOCUMENT TITLE  
Wire, Electrical, Fluoropolymer-Insulated

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

### 5. REASON FOR RECOMMENDATION

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