



## **Raychem Wire and Cable**

501 Oakside Avenue, Redwood City, CA 94063-3800

## **SPECIFICATION:**

**80**

THIS ISSUE: Issue 2  
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PAGE: 1 of 19

### **FLEXLINE WIRE AND CABLE, ELECTRIC, GENERAL PURPOSE, RADIATION-CROSSLINKED, MODIFIED, FLEXIBLE FLUOROPOLYMER-INSULATED**

## **1. SCOPE**

### **1.1 SCOPE**

This specification covers radiation-crosslinked, extruded, modified, flexible fluoropolymer-insulated wire, and single- and multiple-conductor cables which may be shielded and jacketed. This flexible insulation is highly flame retarded and is intended for use as a high-temperature, thin-wall insulation system in military, aerospace, and general wire hook-up applications.

### **1.2 CLASSIFICATION**

Products in accordance with this specification shall be of the following types, as specified in the applicable specification sheet.

**Finished Wire** A single conductor, insulated as specified in the applicable specification sheet.

**Finished Cable** Any construction other than finished wire, utilizing a wire or wires with or without shielding, or with or without an outer jacket.

### **1.3 TEMPERATURE RATING**

The maximum conductor temperature of the finished wire and cable for continuous use shall be as specified in the applicable specification sheet.

## **2. APPLICABLE DOCUMENTS**

### **2.1 GOVERNMENT-FURNISHED DOCUMENTS**

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

2.1.1 Department of Defense

## SPECIFICATIONS

Federal

UU-T-450            Tissue, Facial

Military

MIL-PRF-5606    Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance  
 MIL-DTL-5624    Turbine Fuel, Aviation, Grades JP-4 and JP-5  
 MIL-PRF-7808    Lubricating Oil, Aircraft Turbine Engine, Synthetic Base  
 MIL-PRF-23699   Lubricating Oil, Aircraft Turbine Engine, Synthetic Base  
 MIL-DTL-83133   Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35.  
                          And JP-8+100 (NATO F-37)

## STANDARDS

Federal

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

Military

MIL-STD-104     Limits for Electrical Insulation Color  
 MIL-STD-129     Marking for Shipment and Storage  
 MIL-STD-681     Identification Coding and Application of Hook Up and Lead Wire  
 MIL-STD-2223    Test Methods for Insulated Electric Wire

(Copies of Department of Defense documents may be obtained from the Naval Publications and Forms Center, Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094; or at <https://quicksearch.dla.mil>.)

2.1.2 Department of Transportation, Federal Aviation Administration

## FEDERAL AVIATION REGULATIONS (FAR)

Part 25              Airworthiness Standards: Transport Category Airplanes

(Copies of Department of Transportation, Federal Aviation Administration documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402; or at [www.faa.gov](http://www.faa.gov).)

## 2.2 OTHER PUBLICATIONS

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

### 2.2.1 American Society for Quality (ASQ)

#### Z1.4 Sampling Procedures and Tables for Inspection by Attributes

(Copies of ASQ documents may be obtained from the American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203; or at [www.asq.org](http://www.asq.org).)

### 2.2.2 American Society for Testing and Materials (ASTM)

#### D 770 Isopropyl Alcohol D 882 Tensile Properties of Thin Plastic Sheeting

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959; or at [www.astm.org](http://www.astm.org).)

### 2.2.3 International Organization for Standardization (ISO)

#### 8402 Quality Management and Quality Assurance – Vocabulary

(Copies of ISO documents may be obtained from the International Organization for Standardization; or at [www.iso.org](http://www.iso.org).)

### 2.2.4 National Electrical Manufacturers Association (NEMA)

#### WC 27500 Standard for Aerospace and Industrial Electrical Cable

(Copies of NEMA documents may be obtained from the National Electrical Manufacturers Association, 1300 North 17<sup>th</sup> Street, Rosslyn, VA 22209; or at [www.nema.org](http://www.nema.org).)

### 2.2.5 Society of Automotive Engineers, Inc. (SAE)

#### AS1241 Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft AS22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy AS29606 Wire, Electrical, Stranded, Uninsulated Copper, Copper Alloy, or Aluminum, or Thermocouple Extension, General Specification For

(Copies of SAE aerospace standards may be obtained from SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; or at [www.sae.org](http://www.sae.org).)

## 3. REQUIREMENTS

### 3.1 SPECIFICATION SHEETS

The requirements for the individual wires and cables furnished under this specification shall be as specified herein and in accordance with the applicable specification sheet. In case of conflict, the requirements of the specification sheet shall govern.

## 3.2 QUALIFICATION

The qualification requirements specified herein characterize particular properties that are applicable to all products covered by this specification. Specific wire and cable constructions, as described in 4.2.1, are representative of the types of products furnished under this specification and are used to demonstrate the ability to meet the qualification tests specified herein (see 4.2).

## 3.3 MATERIALS AND CONSTRUCTION

Materials not specifically designated herein shall be of the quality and form best suited for the purpose intended. Unless otherwise specified, materials and construction shall meet the following requirements:

### 3.3.1 Conductor

Copper and copper alloy conductor materials and standard AS29606 conductor (81 series part numbers) constructions shall be in accordance with AS29606. All other conductor materials and constructions (e.g., 82 series part numbers with high-strand-count conductors) shall be as specified in the applicable specification sheet. For the 82 series conductors, the minimum allowable number of strands may be 98 percent of the number specified in the applicable specification sheet, as long as the dimensional and resistance requirements are met.

### 3.3.2 Shield

Shield strands shall conform to the requirements for conductor materials (3.3.1) and shall be constructed in accordance with WC 27500 and the applicable specification sheet.

#### 3.3.2.1 Flat Wire Shield

Flat wire shields shall be constructed from strands which have been formed by flattening round wire strands. After flattening, the strands shall meet the coating thickness and continuity requirements of the appropriate round wire strand material.

### 3.3.3 Insulation and Jacket

All insulations and jackets shall be extruded, low-outgassing, radiation-crosslinked modified, flexible fluoropolymer, and shall be constructed as specified in the applicable specification sheet.

#### 3.3.3.1 Insulation Material Under Conductor Strands

When stranded conductors are used in the construction of the finished wire, there shall be no insulation under any of the strands of the conductor.

### 3.4 IN-PROCESS REQUIREMENTS

#### 3.4.1 Conductor Elongation and Break Strength (High-Strand-Count Conductor)

##### 3.4.1.1 Soft or Annealed Copper

The elongation for high-strand-count soft or annealed copper conductors shall be 5 percent, minimum average, for the whole stranded conductor of regular bunch constructions, or for one whole member from rope bunch constructions, as applicable, removed from the finished wire. There shall be no break strength requirements for soft or annealed copper conductors.

##### 3.4.1.2 High-Strength Copper Alloy

The elongation for high-strand-count high-strength copper alloy conductors shall be 5 percent, minimum average, for the whole stranded conductor removed from the finished wire. The minimum break strength for high-strength copper alloy conductors shall conform to the following:

AWG <u>Size</u>	Minimum <u>Break Strength (lbs)</u>
28	7.10
26	10.7
24	17.8
22	24.0
20	40.0
18	70.3
16	110.

#### 3.4.2 Conductor Splices

Splices shall be in accordance with AS29606.

#### 3.4.3 Insulation Flaws

One hundred percent of the wire shall pass the impulse dielectric test or the spark test of AS22759 at any designated point or points in the manufacturing process prior to completion of the finished wire, using the voltage specified in the applicable specification sheet.

### 3.5 FINISHED WIRE AND CABLE

Finished wire and cable shall conform to the applicable requirements of 3.5.1 to 3.5.14, Table 1 and the applicable specification sheet.

#### 3.5.1 Blocking

Adjacent turns and layers of wire insulation or cable jacket shall not block after specimens are subjected to  $200 \pm 3^{\circ}\text{C}$ . Blocking shall be defined as a transfer of material between adjacent surfaces when they are separated.

**TABLE 1**  
**REQUIREMENTS FOR FINISHED WIRE AND CABLE**

EXAMINATION OR TEST	REQUIREMENT	TEST METHOD	TEST TYPE <u>1/</u>
<b><u>Finished Wire</u></b>			
Blocking	3.5.1 and AS22759	AS22759	Q
Color	3.5.2	4.6.6	1
Concentricity	Specification Sheet	AS22759	2
Conductor Continuity (AWG 8 & larger only)	3.5.3 and WC 27500	WC 27500	3
Conductor Diameter	Specification Sheet	4.6.2	1
Conductor Elongation and Break Strength:			
– Standard AS29606 Conductor (81 series part numbers)	AS29606	AS29606	1
– High-Strand-Count Conductor (82 series part numbers)	3.4.1	4.6.3	1
Conductor Material	3.3.1	4.6.6	1
Conductor Resistance	Specification Sheet	AS29606	1
Conductor Stranding	Specification Sheet	4.6.6	1
Crosslinking Proof Test	Specification Sheet and 3.5.4	4.6.4	2
Finished Wire Diameter	Specification Sheet	4.6.2	1
Flammability	3.5.5	4.6.7	Q
Identification and Color Striping Durability	Specification Sheet	AS22759	1
Identification of Product	3.5.6	4.6.6	1
Immersion	3.5.7	4.6.8	Q
Insulation Elongation and Tensile Strength	Specification Sheet	4.6.9	1
Insulation Flaws	Specification Sheet and 3.5.8	AS22759	3
Insulation Material and Construction	3.3.3	4.6.6	1
Insulation Resistance	3.5.9	AS22759	Q
Insulation Thickness	Specification Sheet	4.6.6	2
Life Cycle	3.5.12	4.6.12	Q
Low Temperature-Cold Bend	3.5.13 and AS22759	AS22759	Q
Removability of Insulation	AS22759	AS22759	1
Secant Modulus	3.5.14	4.6.13	Q
Shrinkage	Specification Sheet	AS22759	2
Weight	Specification Sheet	AS22759	1
Workmanship	AS22759	AS22759	1

(continued)

**TABLE 1 (CONTINUED)**  
**REQUIREMENTS FOR FINISHED WIRE AND CABLE**

EXAMINATION OR TEST	REQUIREMENT	TEST METHOD	TEST TYPE <u>1/</u>
<b>Finished Cable</b>			
Blocking	3.5.1 and WC 27500	WC 27500	Q
Cabling	WC 27500	WC 27500	1
Conductor and Shield Continuity	3.5.3 and WC 27500	WC 27500	3
Crosslinking Proof Test	Specification Sheet and 3.5.4	4.6.4	2
Dielectric Withstand	Specification Sheet	WC 27500	3
Dimensions	Specification Sheet	4.6.6	1
Flammability	3.5.5	4.6.7.1	Q
Identification of Product	3.5.6	4.6.6	1
Immersion	3.5.7	4.6.8	Q
Jacket Color	3.5.2	4.6.6	1
Jacket Concentricity	3.5.10	4.6.10	2
Jacket Elongation and Tensile Strength	Specification Sheet	4.6.9	1
Jacket Flaws	Specification Sheet and 3.5.11	4.6.11	3
Jacket Material and Construction	3.3.3	4.6.6	1
Jacket Thickness	Specification Sheet	4.6.6	2
Life Cycle	3.5.12	4.6.12	Q
Low Temperature-Cold Bend	3.5.13 and WC 27500	WC 27500	Q
Secant Modulus	3.5.14	4.6.13	Q
Shield Material and Construction	3.3.2	WC 27500	1
Shield Coverage	Specification Sheet	WC 27500	1
Weight	Specification Sheet	4.6.15	1
Workmanship	WC 27500	WC 27500	1

**1/ TEST TYPE:**

- Q = Qualification Test (4.2)
- 1 = Quality Conformance Test, Group 1 (4.3)
- 2 = Quality Conformance Test, Group 2 (4.3)
- 3 = Quality Conformance Test, Group 3 (4.3)
- P = Process Control Inspection (4.4)

### 3.5.2 Color

Color shall be in accordance with MIL-STD-104, Class 1. White is preferred for both insulation and jacket. Color code designators, and colored stripes and bands, if used, shall be in accordance with MIL-STD-681.

### 3.5.3 Conductor and Shield Continuity

When finished cable and AWG 8 and larger finished wire is tested in accordance with WC 27500, there shall be no loss of continuity in the conductors or shield.

### 3.5.4 Crosslinking Proof Test

When finished wire and cable is tested in accordance with 4.6.4, there shall be no cracking of the insulation or jacket and no dielectric breakdown.

### 3.5.5 Flammability

When qualification samples are tested in accordance with 4.6.7, the burn length shall not exceed 3 inches (76 mm), the afterburn time shall not exceed 3 seconds, and there shall be no flaming of the facial tissue.

### 3.5.6 Identification of Product

When specified by the procuring activity, finished wire or cable shall be identified by a marking applied to the outer surface. The identification shall consist of the appropriate mark as specified by the contract or the applicable specification sheet. For wire sizes AWG 10 and smaller, the legend shall be printed in black ink, except where black ink is difficult to read, the printing shall be in a contrasting color. For wire sizes AWG 8 and larger, the legend shall be printed in black ink preferably. For all other marking surfaces, the legend shall be printed in a contrasting color. Identification shall be applied with the vertical axis of the printed characters parallel to the longitudinal axis of the wire or cable when the nominal diameter of the marking surface is 0.050 inch (1.3 mm) or smaller. The vertical axis of the printed characters may be either perpendicular or parallel to the longitudinal axis of the wire or cable when the nominal diameter of the marking surface exceeds 0.050 inch (1.3 mm). Wires with diameters of 0.035 inch (0.89 mm) and smaller shall not be marked.

### 3.5.7 Immersion

When qualification samples are tested in accordance with 4.6.8, the diameter change shall be no more than 5 percent, and there shall be no cracking of the insulation or jacket and no dielectric breakdown.

### 3.5.8 Insulation Flaws

One hundred percent of finished wire shall pass the impulse dielectric test or the spark test of AS22759 using the voltage specified in the applicable specification sheet. The test shall be performed during the final winding of the wire on shipment spools or reels.



### 3.5.9 Insulation Resistance

The minimum insulation resistance for 1000 feet of the wire specimens shall be 500 megohms ( $152.4\text{ M}\Omega\text{-}1\text{ km}$ ) for AWG 22 and 20, and 100 megohms ( $30.5\text{ M}\Omega\text{-}1\text{ km}$ ) for AWG 8.

### 3.5.10 Jacket Concentricity

When finished cable is tested in accordance with 4.6.10, the jacket concentricity shall be 70 percent, minimum.

### 3.5.11 Jacket Flaws

One hundred percent of finished shielded and jacketed cable shall pass the jacket flaws test of 4.6.11 using the voltage specified in the applicable specification sheet.

### 3.5.12 Life Cycle

When tested in accordance with 4.6.12, using a test temperature of  $230 \pm 3^\circ\text{C}$  for the AWG 8 specimen, and  $200 \pm 3^\circ\text{C}$  for the other specimens, qualification samples shall exhibit no cracking of the insulation or jacket and no dielectric breakdown.

### 3.5.13 Low Temperature-Cold Bend

When qualification samples are tested at  $-65 \pm 3^\circ\text{C}$ , there shall be no cracking of the insulation or jacket and no dielectric breakdown. The test mandrels and weights specified for the corresponding wire sizes in AS22759/34 and in AS22759/32 shall be used for the 81A081x and 82A011x wire samples, respectively.

### 3.5.14 Secant Modulus

When tested in accordance with 4.6.13, the secant modulus shall not exceed  $5.0 \times 10^4\text{ lbf/in}^2$  ( $345\text{ N/mm}^2$ ) for AWG 22 and 20 wire specimens, or  $4.0 \times 10^4\text{ lbf/in}^2$  ( $276\text{ N/mm}^2$ ) for cable and AWG 8 wire specimens.

## 4. **QUALITY ASSURANCE PROVISIONS**

### 4.1 **RESPONSIBILITY FOR INSPECTION**

The supplier is responsible for the performance of all the inspection tests specified herein. The supplier may utilize his own or any other inspection facility and services acceptable to the buyer. Inspection records of the examination and tests shall be kept complete and available to the buyer as required.

### 4.2 **QUALIFICATION INSPECTION**

Qualification inspection shall consist of all tests in Table 1, as applicable to finished wire or to finished cable.

#### 4.2.1 Qualification Samples

Qualification samples shall consist of the following part numbers (insulation/jacket colors shall be optional):

81A081x-22	<i>(will qualify all dual-wall primary wire, AWG 10 and smaller)</i>
81A081x-8	<i>(will qualify all dual-wall primary wire, AWG 8 and larger)</i>
82A011x-20	<i>(will qualify all single-wall primary wire)</i>
82A112x-20	<i>(will qualify all cable constructions)</i>

The “x” in the part numbers above shall be replaced by a conductor material designator, which, for qualification samples, may be either “1” or “3” (tin- or nickel-coated copper, respectively).

#### 4.2.2 Qualification Test Reports

When requested by the procuring activity, qualification test reports shall be supplied plainly identified with the following information:

Qualification test report for  
**FLEXLINE WIRE AND CABLE,**  
**ELECTRIC, GENERAL PURPOSE,**  
**RADIATION-CROSSLINKED MODIFIED,**  
**FLEXIBLE FLUOROPOLYMER-INSULATED**  
 Name of Manufacturer  
 Part number of qualification sample  
 Part numbers qualified  
 Specification 80

#### 4.3 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection shall consist only of those examinations and tests listed in Table 1 and identified by a group number, as applicable to finished wire or to finished cable. Quality conformance inspection shall be performed on every lot of wire or cable procured under this specification.

##### 4.3.1 Sampling for Quality Conformance Inspection

ISO 8402 shall apply for definitions of inspection terms used herein. For purposes of this specification, the following shall apply:

##### 4.3.1.1 Lot

The inspection lot shall include all wire and cable of one-part number subjected to inspection at one time.

##### 4.3.1.2 Unit of Product

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

#### 4.3.1.3 Sample Unit (Groups 1 and 2 tests)

The sample unit for Groups 1 and 2 tests shall consist of a single length of finished wire or cable 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 1 tests of Table 1 shall be 20 feet (6.1 m) and the length of the sample unit for Group 2 tests shall be 25 feet (7.6 m). Not more than one sample unit for each group of tests shall be taken from a single unit of product.

#### 4.3.1.4 Inspection Levels and Acceptable Quality Levels (AQL) (Groups 1 and 2 tests)

For Group 1, the inspection level shall be S-2 and the AQL shall be 6.5 percent in accordance with ASQ Z1.4; for Group 2, the inspection level shall be S-3 and the AQL shall be 1.5 percent.

#### 4.3.1.5 Sampling and Acceptance Level for Group 3 Tests

Unless otherwise specified in the applicable specification sheet, the finished wire or cable sample for the Group 3 tests shall be 100 percent of the finished wire or cable, and every length of the wire or cable shall be fully tested. Portions showing breakdown in these dielectric tests, and ends or portions not subjected to these tests, shall be marked or removed and the remaining lengths tested until no failure occurs.

#### 4.3.2 Nonconforming Inspection Lots

Disposition of inspection lots found unacceptable under initial quality conformance inspection shall be in accordance with ASQ Z1.4.

### 4.4 PROCESS CONTROL INSPECTION

This inspection comprises tests and examinations (Table 2) of such a nature that they cannot be performed on the finished wire or cable and therefore must be performed at an appropriate stage of manufacture. Process control inspection shall be performed on every lot of wire or cable procured under this specification.

**TABLE 2**  
**PROCESS CONTROL INSPECTION**

Examination or Test	Requirement	Test Method
Conductor material	3.3.1	4.6.6
Shield material	3.3.2	4.6.6
Insulating and jacketing material	3.3.3	4.6.6
Conductor splices	3.4.2	4.6.6
Insulation flaws	3.4.3	AS22759

#### 4.4.1 Sampling for Process Control Inspection

##### 4.4.1.1 Conductor Material

Process control sample selection and inspection of uninsulated conductor shall be performed at receiving inspection. The conductor lot size, for purposes of sampling, shall consist of the number of reels of a given type and size of conductor received at one time from one supplier against a single purchase order. For lot sizes of 3 reels or less, one 15-foot (4.6-m) length of conductor shall be selected from each reel. For lot sizes of not less than 4 and not more than 25 reels, a minimum of three 15-foot (4.6-m) lengths of conductor shall be selected at random, in such a manner as to be representative of the material. For lot sizes in excess of 25 reels, the inspection level shall be Level 1 and the AQL shall be 4.0 percent in accordance with ASQ Z1.4.

##### 4.4.1.2 Insulation Flaws (Impulse Dielectric Test or Spark Test)

One hundred percent of the wire, after the application of the primary insulation, shall be tested in accordance with the applicable specification sheet and AS22759.

#### 4.4.2 Rejection and Retest in Process Control Inspection

When a sample selected from an inspection lot fails to meet the specified test (Table 2), except the insulation flaws test (see 4.4.1.2), no items still on hand or later produced from that lot shall be accepted until the extent and cause of the failure has been determined.

##### 4.4.2.1 Effect of Process Control Failure on Quality Conformance Testing

Quality conformance testing may be continued during the investigation of a failure of a process control sample, but final acceptance of the material shall not be made until it is determined that the lot meets all the process control and quality conformance requirements of the specification.

#### 4.5 PERIODIC QUALIFICATION RE-EVALUATION

Qualification re-evaluation shall be performed, at the manufacturer's discretion, whenever any significant change is made to the materials or manufacturing process.

#### 4.6 TEST METHODS

##### 4.6.1 Bend Test (Post-Environmental)

At a temperature maintained between 20 and 25°C, one end of a finished wire specimen shall be secured to the mandrel and the other end to the weight specified in the applicable specification sheet. For finished cable specimens, the mandrel shall be as specified in Table 3 and sufficient weight shall be used to maintain contact with the mandrel. 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 turns in contact. The mandrel shall then be rotated in the reverse direction until the full length of the specimen 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 specimen. The specimen shall then be examined for cracking of the insulation or jacket, as applicable.

**TABLE 3**  
**MANDREL DIAMETERS FOR CABLES FOR BEND TEST**  
**(POST-ENVIRONMENTAL)**

Finished Cable Diameter		Mandrel Diameter	
inch	mm	inch	mm
$\leq 0.083$	$\leq 2.11$	.750	19
$> 0.083$ and $\leq 0.111$	$> 2.11$ and $\leq 2.82$	1.00	25
$> 0.111$ and $\leq 0.139$	$> 2.82$ and $\leq 3.53$	1.25	32
$> 0.139$ and $\leq 0.194$	$> 3.53$ and $\leq 4.93$	1.75	44
$> 0.194$ and $\leq 0.250$	$> 4.93$ and $\leq 6.35$	2.25	57
$> 0.250$ and $\leq 0.334$	$> 6.35$ and $\leq 8.48$	3.00	76
$> 0.334$ and $\leq 0.444$	$> 8.48$ and $\leq 11.3$	4.00	102
$> 0.444$ and $\leq 0.556$	$> 11.3$ and $\leq 14.1$	5.00	127
$> 0.556$ and $\leq 0.667$	$> 14.1$ and $\leq 16.9$	6.00	152
$> 0.667$ and $\leq 0.889$	$> 16.9$ and $\leq 22.6$	8.00	203
$> 0.889$ and $\leq 1.111$	$> 22.6$ and $\leq 28.2$	10.0	254
$> 1.111$ and $\leq 1.556$	$> 28.2$ and $\leq 39.5$	14.0	356
$> 1.556$ and $\leq 2.000$	$> 39.5$ and $\leq 50.8$	18.0	457

#### 4.6.2 Conductor and Finished Wire Diameter

Diameter measurements shall be made on a 24-inch (610-mm), minimum, length of finished wire taken from the end of the sample unit. The conductor shall be made accessible by stripping and removing the insulation carefully so as not to nick, cut, cold-work, or otherwise damage the conductor. Three points for measurement shall be located 8 inches (203 mm) apart along the conductor or finished wire specimen length, as applicable. For AWG 10 and smaller, measurements shall be made at each point at two approximately perpendicular planes or as required to assure that the minimum and maximum reading is attained at each point. A total of six measurements shall be performed on each specimen. Measurements shall be made with a micrometer caliper or equivalent device capable of resolving a measurement to 0.0001 inch (0.0025 mm). For AWG 8 and larger, a circumferential measuring tape may be used in lieu of a micrometer, and a total of three measurements, taken 8 inches (203 mm) apart, shall be performed on each specimen. The circumferential measuring tape shall be capable of resolving a measurement to 0.001 inch (0.025 mm) over a diameter range of 0.200 inch (5.08 mm) and larger. The average diameter of all applicable measurements shall be calculated and recorded.

#### 4.6.3 Conductor Elongation and Break Strength (High-Strand-Count Conductor)

##### 4.6.3.1 Soft or Annealed Copper

Elongation tests of soft or annealed copper conductors shall be tested in accordance with MIL-STD-2223, Method 5002, using a 10-inch (254-mm) initial jaw separation and a jaw separation speed of  $10 \pm 2$  inches ( $254 \pm 51$  mm) per minute. The test shall be performed upon the whole conductor for regular bunch-stranded constructions, or upon one whole member removed from rope bunch-stranded constructions, as applicable, taken from the finished wire. In either case, elongation shall be measured upon breakage of the first strand of the whole conductor or member, as applicable. Elongation shall be determined by the distance the jaw has traveled. Breaks occurring at the jaws shall be discounted and a new specimen shall be tested.

#### 4.6.3.2 High-Strength Copper Alloy

Elongation and break strength tests of high-strength copper alloy conductors shall be tested in accordance with MIL-STD-2223, Method 5002 on the whole conductor removed from the finished wire, using a 10-inch (254-mm) initial jaw separation and a jaw separation speed of  $2 \pm 0.5$  inches ( $51 \pm 13$  mm) per minute. Elongation shall be determined by the distance the jaw has traveled. Breaks occurring at the jaws shall be discounted and a new specimen shall be tested.

#### 4.6.4 Crosslinking Proof Test

Crosslinking proof tests of finished wire and cable shall be conducted in accordance with the life cycle test method of 4.6.12. The time and temperature specified for the crosslinking proof test on the applicable specification sheet shall be used.

#### 4.6.5 Examination of Preparation for Delivery

Preparation for delivery of materials ready for shipment shall be examined to determine compliance with the requirements of Section 5.

#### 4.6.6 Examination of Product

All samples of wire and cable shall be examined to determine conformance with this specification and the applicable specification sheet with regard to requirements not covered by specific test methods.

#### 4.6.7 Flammability

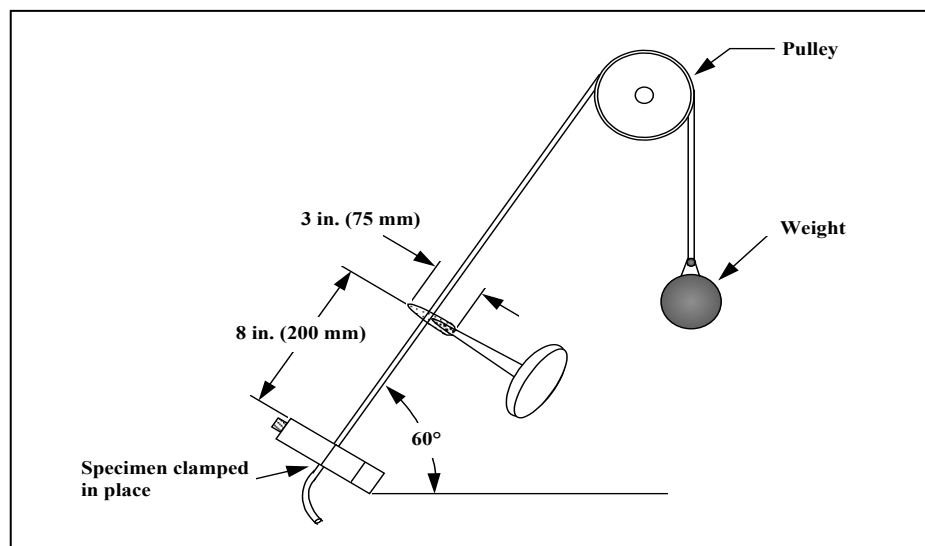
The following test method conforms to FAR Part 25, Appendix F, Part I, and includes a provision for the detection of incendiary dripping.

##### 4.6.7.1 Test Apparatus

The test shall be performed within a test chamber approximately 1-foot (0.30 m) square by 2 feet (0.61 m) in height, open at the top and front to provide adequate ventilation for combustion but to prevent drafts. The specimen holder shall be so designed that the lower end of a 24-inch (610-mm) specimen is held by a clamp, while the upper end of the specimen passes over a pulley and can be suitably weighted to hold the specimen taut at an angle of 60 degrees with the horizontal, in a plane parallel to and approximately 6 inches (152 mm) from the back of the chamber. The test flame shall originate from a Bunsen type gas burner with a 0.250-inch (6.4-mm) inlet, a needle valve in the base for gas adjustment, a nominal bore of 0.375 inch (9.5 mm), and a barrel length of approximately 4 inches (102 mm) above the air inlets. The burner shall be adjusted to furnish a 3-inch (76-mm) high conical flame with an inner cone approximately 1 inch (25 mm) in length and a flame temperature not less than 954°C at its hottest point, as measured with an accurate thermocouple pyrometer. A sheet of facial tissue conforming to UU-T-450 shall be suspended taut and horizontal 9.5 inches (241 mm) below the point of application of the flame to the specimen and at least 0.50 inch (13 mm) from the chamber floor, so that any material dripping from the specimen shall fall upon the tissue.

#### 4.6.7.2 Test Procedure

A 24-inch (610-mm) specimen shall be marked at a distance of 8 inches (203 mm) from its lower end to indicate the point for flame application and shall be placed in the specified 60-degree position in the test chamber. The lower end of the specimen shall be clamped in position in the specimen holder and the upper end shall be passed over the pulley of the holder and the appropriate weight shall be attached. Weight shall be sufficient to hold the specimen taut throughout the test. With the burner held perpendicular to the specimen and at an angle of 30 degrees from the vertical plane of the specimen (see Figure 1), the hottest portion of the flame shall be applied to the lower side of the specimen at the test mark. The period of test flame application shall be 30 seconds and the test flame shall be withdrawn immediately at the end of that period. The distance of flame travel upward along the specimen from the test mark and the time of burning after removal of the test flame shall be recorded; also, the presence or absence of flame in the facial tissue due to incendiary dripping from the specimen. Charred holes or charred spots in the tissue shall be ignored in the absence of actual flame. Breaking of the specimen shall not be considered as failure, provided the requirements for flame travel limits, duration of flame, and the absence of incendiary dripping are met.



**FIGURE 1.**  
**Flammability Test Apparatus (shown without chamber)**

#### 4.6.8 Immersion

Specimens of sufficient length to perform the subsequent tests shall be measured at their midpoints to determine their initial diameters and shall then be immersed to within 6 inches (152 mm) of their ends in each of the fluids (using a separate specimen for each fluid) for the time and temperature specified in Table 4. During immersion, the radius of bend of the specimens shall be not less than 14, nor more than 35, times the specified maximum diameter of the wire or cable under test. Upon removal from the fluids, the specimens shall remain for 1 hour in free air at room temperature. The diameters shall then be remeasured at the original point of measurement and compared to the initial diameters. The percent change in diameter shall then be calculated. For finished wire, 1-inch (25 mm) of insulation shall be removed from each end of a 24-inch (610-mm) length of each specimen. For finished cable, 2 inches (51 mm) of the jacket shall be removed from each end of a 24-inch (610-mm) length of each specimen,



and the shield shall be pushed back and formed into a pigtail at each end of the specimen. One inch (25 mm) of insulation of each of the primary wires shall then be removed from each end of the specimen. The specimens shall then be subjected to the bend test (4.6.1, using the mandrels and test weights specified on the applicable specification sheet for the Crosslinking Proof Test), followed by the voltage withstand test (4.6.14).

**TABLE 4**  
**IMMERSION TEST FLUIDS**

	TEST FLUID	TEST TEMPERATURE	IMMERSION TIME
(a)	MIL-PRF-23699, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	48 to 50°C (118 to 122°F)	20 hours
(b)	MIL-PRF-5606, Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance	48 to 50°C (118 to 122°F)	20 hours
(c)	ASTM D 770, Isopropyl Alcohol	20 to 25°C (68 to 77°F)	168 hours
(d)	MIL-DTL-5624, Turbine Fuel, Aviation, Grade JP-4, or JP-8 per MIL-DTL-83133	20 to 25°C (68 to 77°F)	168 hours
(e)	AS1241, Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft	48 to 50°C (118 to 122°F)	20 hours
(f)	MIL-PRF-7808, Lubricating Oil, Aircraft Turbine Engine, Synthetic Base; or NATO 148	118 to 121°C (244 to 250°F)	30 minutes

#### 4.6.9 Insulation/Jacket Elongation and Tensile Strength

Specimens of the entire insulation 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, using 1-inch (25-mm) bench marks, a 1-inch (25-mm) initial jaw separation, and a jaw separation speed of 2 inches (51 mm) per minute. For cables, the method shall be the same, but only the cable jacket shall be tested.

#### 4.6.10 Jacket Concentricity

The concentricity of the cable jacket shall be determined by first locating and recording the minimum wall thickness measured on a cross-section of the jacket. The maximum wall thickness of this same cross-section of the jacket shall also be measured and recorded. The ratio of the minimum wall thickness to the maximum wall thickness shall define the concentricity. All wall thickness measurements shall be made under suitable magnification. The wall thickness shall be the radial distance between the inner and outer rim of the jacket.

#### 4.6.11 Jacket Flaws

Finished cable shall be tested in accordance with the jacket flaws test of WC 27500, or the impulse dielectric test procedure of AS22759, with the shield grounded at one or both ends.

#### 4.6.12 Life Cycle

Finished wire and cable specimens, prepared in accordance with 4.6.12.1 or 4.6.12.2, as applicable, shall be conditioned in an air-circulating oven for 500 hours at the temperature specified. The velocity of air past the specimens (measured at room temperature) shall be between 100 and 200 feet (30 and 61 m) per minute. After conditioning, the oven shall be shut off, the door opened, and the specimens allowed to cool in the oven for at least 1 hour. When



cool, the finished wire specimens shall be freed from tension, removed from the mandrel, and straightened. All finished wire and cable specimens shall then be subjected to the bend test (4.6.1). The voltage withstand test (4.6.14) shall then be conducted on finished wire and shielded-and-jacketed specimens only.

#### 4.6.12.1 Finished Wire Preparation

One-inch (25 mm) of insulation shall be removed from each end of a 24-inch (610-mm) specimen of finished wire. The central portion of the specimen shall then be bent at least halfway around a horizontally positioned smooth stainless-steel mandrel of the diameter specified in the applicable specification sheet for the Crosslinking Proof Test. To prevent sticking of the specimen to the mandrel, the mandrel shall be covered with polytetrafluoroethylene in the form of either a dispersion coating (preferred) or wrapped tape, provided that the diameter of the mandrel still conforms to the applicable specification sheet. Each end of the conductor shall be loaded with the weight specified in the applicable specification sheet for the Crosslinking Proof Test (except that for 200°C rated wire, AWG 22 and 20, the weight shall be 25 percent of that specified for the Crosslinking Proof Test), so that the portion of the insulation between the conductor and mandrel is under compression while the conductor is under tension. This specimen, so prepared on the mandrel, shall be conditioned and tested as specified in 4.6.12.

#### 4.6.12.2 Finished Cable Preparation

Two inches (51 mm) of the jacket shall be removed from each end of a 15-inch (380-mm) specimen of finished cable, and the shield, if any, shall be pushed back and formed into a pigtail at each end of the specimen. One inch (25 mm) of insulation of each of the primary wires shall then be removed from each end of the specimen. The cable specimen shall then be loaded with sufficient weight to hang straight and shall be conditioned and tested as specified in 4.6.12.

#### 4.6.13 Secant Modulus

Specimens of the wire insulation, or cable jacket, shall be carefully removed and tested for secant modulus in accordance with ASTM D 882, using a 2-inch (50-mm) initial jaw separation, a jaw speed of 0.2 inch (5 mm) per minute, and a chart speed of 20 inches (508 mm) per minute. The pounds-force (N) shall be read from the chart 4 inches (102 mm) from where the trace begins to rise for 0 pounds-force (N).

$$\text{Secant Modulus (lbsf/in}^2 \text{ @ 2\%)} = \frac{\text{lbsf}}{\text{CSA} \times 0.2}$$

Where: CSA = cross sectional area

#### 4.6.14 Voltage Withstand

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, except that the uninsulated ends and 1.5 inches (38 mm) of insulated wire or cable 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 shall be applied at 60 Hz between the conductor or the shield, as applicable, and an electrode in contact with the liquid. The voltage shall be gradually increased at a uniform rate from zero to the specified voltage in 0.5 minute, maintained at that voltage for a period of 5 minutes for finished wire specimens and 1 minute for finished cable specimens, and then gradually reduced to zero in 0.5 minute.

#### 4.6.15 Weight

The weight of each lot of finished cable shall be determined in accordance with the procedure specified for finished wire in AS22759.

### 5. PREPARATION FOR DELIVERY

#### 5.1 PACKAGING AND PACKING

Wire and cable shall be delivered wound on reels or spools in accordance with 5.1.3.

##### 5.1.1 Winding Requirements

All layers of wire or cable shall be wound on the reel or spool with sufficient tension to prevent shifting of layers and creation of crossovers within layers.

##### 5.1.1.1 Finished Wire

All finished wire lengths wound on one reel or spool shall be spliced into one mechanically and electrically continuous length.

##### 5.1.1.2 Finished Cable

Finished cable shall be wound with no more than 5 lengths per reel or spool, and in such a manner that all ends are accessible.

##### 5.1.2 Lengths

Unless otherwise specified, minimum continuous length (between splices) for finished wire shall be in accordance with Table 5. For finished cable, the minimum acceptable length for shipment shall be 50 feet (15.2 m).

**TABLE 5**  
**FINISHED WIRE LENGTHS**

Wire Size Range		Minimum Percentage of Total Length in Shipment with Lengths Greater Than:		
AWG	mm <sup>2</sup>	500 ft (152 m)	100 ft (30.5 m)	50 ft (15.2 m)
30 through 10	0.057 through 4.74	50	100	---
8 through 0000	8.60 through 106.9	---	---	100

##### 5.1.3 Reels and Spools

Reels and spools shall be of a nonreturnable type. Each reel and 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 3.5 inches (89 mm). Reels and spools shall be suitably finished to prevent corrosion under typical storage and handling conditions.

#### 5.1.4 Containers

Unless otherwise specified (see 6.1), wire and cable shall be delivered in standard commercial containers so constructed as to ensure acceptance by common or other carrier for safe transportation at the lowest rate to the point of delivery.

#### 5.1.5 Marking of Shipments

All spools or reels and shipping containers shall be identified with the following information:

Specification Sheet Part Number  
Lot Number  
Quantity in feet (*or meters*)  
Name of Manufacturer

### 6. **NOTES**

#### 6.1 ORDERING DATA

Procurement documents should specify the following:

- (a) Title, number, and revision of this specification
- (b) Applicable specification sheet part number
- (c) Quantity
- (d) Special preparation for delivery requirements, if applicable

#### 6.2 METRIC UNITS

Metric units are for information only.

#### 6.3 AS22759

Whenever AS22759 refers to the “application detail specification”, use the applicable TE specification sheet (3.1).

#### 6.4 TRADEMARKS

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