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RADIATION-CROSSLINKED, FLEXIBLE, MODIFIED POLYOLEFIN JACKETED MULTI-CONDUCTOR CABLES

1. SCOPE

1.1 SCOPE

This specification covers multi-conductor cables jacketed with a flame retarded, radiation-crosslinked, general purpose, polyolefin blend material. The jacket material possesses excellent flexibility and low temperature properties, as well as abrasion resistance and resistance to a range of fluids.

1.2 TEMPERATURE RATING

The cable jacket material covered by this specification is rated from -55°C to 125°C. The operational temperature of a finished cable will be dependent on, and limited by, the materials used in the construction of the cable and components selected, or it may be operational at higher temperatures for short durations, depending on the application. It is the responsibility of the customer to determine the suitability of the final product for the application.

1.3 CABLE DESIGNATION

Cables shall be identified by a combination of digits and letters in accordance with 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

TT-I-735 Isopropyl Alcohol

Military

MIL-DTL-24640	Cables, Lightweight, Low Smoke, Electric, For Shipboard Use, General Specification For
MIL-PRF-17672	Hydraulic Fluid, Petroleum, Inhibited
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Numbers: O-152, O-154, O-156, and O-167

STANDARDS

Federal

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

Military

MIL-STD-1916	DOD Preferred Methods for Acceptance of Product

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

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.)

2.2 OTHER PUBLICATIONS

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.

2.2.1 American Society for Testing and Materials (ASTM)

D 470	Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable
D 882	Standard Test Method for Tensile Properties of Thin Plastic Sheeting
D 3032	Standard Test Methods for Hookup Wire Insulation

(Copies of ASTM documents 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.)

2.2.2 National Electrical Manufacturers Association (NEMA)

WC 27500 American National Standard for Aerospace and Industrial Electrical Cable

(Copies of NEMA documents may be obtained from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, VA 22209; or at www.nema.org.)

2.2.3 Society of Automotive Engineers (SAE)

AMS1424	Deicing/Anti-Icing Fluid, Aircraft SAE Type I
AS4373	Test Methods for Insulated Electric Wire
AS85485	Cable, Electric, Filter Line, Radio Frequency Absorptive

(Copies of SAE documents may be obtained from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001; or at www.sae.org.)

3. REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 Specification Sheets

The requirements for the component wire and finished cable furnished under this specification shall be as specified herein and in accordance with the applicable specification sheet. In the event of a conflict, the requirements of the specification sheet shall govern.

3.1.2 Components

Unless otherwise specified, component wires or cables shall be as specified in the applicable specification sheet. Components shall meet their own specification requirements prior to cabling.

3.1.3 Cable Properties

The properties of finished cables are indexed in Table 1 and are further detailed in Section 3.

3.2 CLASSIFICATION OF REQUIREMENTS

The applicable requirements are classified herein as follows:

Requirement	Paragraph
Qualification	3.3
Materials	3.4
Construction	3.5
Detail Requirements	3.6

3.3 QUALIFICATION

Cable furnished under this specification shall be constructed from materials having met the requirements of Section 4.3.

3.4 MATERIALS

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

3.4.1 Shield Material

Shield material shall be as specified in the applicable specification sheet and shall meet the material requirements for that type as specified in WC 27500.

3.4.2 Cable Jacket Material

Cable jacket shall be a flame retarded, radiation-crosslinked, polyolefin blend material (Thermorad F).

3.5 CONSTRUCTION

Construction of the finished cable shall be as specified herein and in the applicable specification sheet.

3.5.1 Components

Component wires and cables shall be the type and size as specified in the applicable specification sheet.

3.5.2 Shield Construction and Coverage

3.5.2.1 Braided Shields

The shield shall meet the requirements of the applicable specification sheet. Unless otherwise specified, the shield coverage shall be 85 percent, minimum. The shield shall be free of irregularities, discontinuities, and whole braid splices. Shield coverage and braid angle shall be determined in accordance with WC 27500 when applicable.

3.5.2.2 Foil Shields and Drain Wires

Foil shields and drain wires shall meet the requirements of the applicable specification sheet.

3.5.3 Wraps

Tape wraps, where specified in the applicable specification sheet, shall be applied with an overlap of 25 percent, minimum, and shall meet the material and construction requirements of the applicable specification sheet. Overlap is defined as the percentage of tape width covered by successive turns of tape.

3.5.4 Jacket

The jacket shall be extruded concentrically over the cable core. The jacket shall meet the applicable requirements of Table 1, Table 2, and the applicable specification sheet, and shall be removable without damage to the underlying shield or components.

3.6 DETAIL REQUIREMENTS

Finished cable shall conform to the requirements of Table 1 and to those of the applicable specification sheet.

TABLE 1. PROPERTIES OF FINISHED CABLE

Examination or Test	Requirement	Test Method	*Test Group
Accelerated Aging	3.6.1	4.5.1	1
Attenuation	Specification Sheet	MIL-DTL-24640	1
Cabling	Specification Sheet and 3.6.2	4.5.7	1
Capacitance	Specification Sheet	MIL-DTL-24640	1
Characteristic Impedance	Specification Sheet	4.5.4	1
Color Codes and Methods	3.6.3	4.5.7	1
Conductor and Shield Continuity	3.6.4	4.5.5	2
Conductor and Shield Resistance	Specification Sheet	4.5.6	1
Construction	Specification Sheet and 3.5	4.5.7	1
EMP Response	Specification Sheet	MIL-DTL-24640	1
Finished Cable Diameter	Specification Sheet	ASTM D 3032, Section 15	1
Identification of Finished Cable	3.6.5	4.5.7	1
Insulation Resistance	Specification Sheet and 3.6.6	4.5.9	1
Jacket Concentricity	70% min.	ASTM D 3032, Section 16	1
Jacket Elongation and Tensile Strength	300% min. and 2000 lbf/in^2 *(13.8 MPa)* min.	4.5.10	1
Jacket Flaws	3.6.7	4.5.11	2
Jacket Shrinkage	.250 inch *(6.4 mm)* max.	4.5.12	1
Jacket Thickness	Specification Sheet and 3.6.8	ASTM D 3032, Section 15	1
Materials	Specification Sheet and 3.4	4.5.3	1
Shield Construction and Coverage	3.5.2	WC 27500	1
Strength Member Breaking Stress	Specification Sheet and 3.6.9	4.5.14	1
Surface Transfer Impedance	Specification Sheet and 3.6.10	4.5.15	1
Voltage Withstand (Dielectric)	Specification Sheet and 3.6.11	4.5.16.1	2
Weight	Specification Sheet	4.5.17	1
Workmanship	3.6.12	4.5.7	1

* Test Group (see 4.4):

1 = Quality Conformance, Group 1
2 = Quality Conformance, Group 2

TABLE 2. PROPERTIES OF JACKET MATERIAL (for CJMS232-14)

Examination or Test	Requirement	Test Method
Aging Stability	Specification Sheet	4.5.2
Cold Bend	Specification Sheet	AS4373, Method 702
Concentricity	Specification Sheet	AS4373, Method 101
Conductor Diameter	Specification Sheet	AS4373, Method 401
Conductor Material	Specification Sheet	4.5.3
Conductor Stranding	Specification Sheet	4.5.7
Dynamic Cut-Through	Specification Sheet	AS4373, Method 703
Finished Wire Diameter	Specification Sheet	AS4373, Method 901
Flammability	Specification Sheet	FAR Part 25, Appendix F, Part 1, 60° test
Fluid Immersion	Specification Sheet	4.5.8
Insulation Elongation and Tensile Strength	Specification Sheet	AS4373, Method 705
Insulation Flaws	Specification Sheet	AS4373, Method 505
Insulation Resistance	Specification Sheet	AS4373, Method 504
Needle Abrasion Test	Specification Sheet	AS4373, Method 301
Secant Modulus	Specification Sheet	4.5.13
Tear Strength	Specification Sheet	ASTM D 470
Workmanship	3.6.12	4.5.7

3.6.1 Accelerated Aging

When specimens of the finished cable jacket are tested in accordance with 4.5.1, the elongation and tensile strength retention shall be 60 percent, minimum, of the original values.

3.6.2 Cabling

3.6.2.1 Configuration

The required number of components as specified in the applicable specification sheet shall be cabled together with a left-hand lay. For cables having multiple layers, the outer layer shall be left-hand and the inner layer or layers may be either right-hand or left-hand lay. The lay length of the components in the outer layer shall be not less than eight nor more than sixteen times the outside diameter of the cable bundle.

3.6.2.2 Cabling Sequence

In the case of cables having more than one layer of components, the component numbering sequence, when applicable, shall be from the innermost to the outermost; i.e., component number 1 shall be the center component (or one of the center components where two or more are used as a center) of the concentric layup.

3.6.2.3 Fillers and Binders

Fillers and binders shall be used as necessary to produce a firm round cable. Filler and binder material shall be moisture resistant and shall be compatible with all other cable components.

3.6.3 Color Codes and Methods

3.6.3.1 Wire and Component Identification - General

Individual wires, or individual wires of component groups, shall be identified in accordance with the applicable specification sheet. Where colored insulation, stripes, bands, or other marks are used, color designations are as follows:

Number	Color	Number	Color
0	Black	5	Green
1	Brown	6	Blue
2	Red	7	Violet
3	Orange	8	Gray
4	Yellow	9	White

An "L" suffix on the number indicates a lighter variation; e.g., 2L is pink. Where printed characters are used for identification, the vertical axis of the characters may be either perpendicular or parallel to the longitudinal axis of the wire. The spacing between legends shall be 3 inches *(76 mm)*, nominal. Character height shall be proportional to the substrate diameter as follows:

Diameter Range		Height of Character (Approx.)	
Inch	*mm*	Inch	*mm*
0.045 to 0.070	*1.1 to 1.8*	0.025	*0.64*
0.070 to 0.095	*1.8 to 2.4*	0.031	*0.79*
0.095 to 0.115	*2.4 to 2.9*	0.047	*1.2*
0.115 to 0.200	*2.9 to 5.1*	0.063	*1.6*
0.190 to 0.250	*4.8 to 6.4*	0.078	*2.0*
0.235 to 0.375	*6.0 to 9.5*	0.094	*2.4*
0.375 and larger	*9.5 and larger*	0.125	*3.2*

3.6.3.2 Wire and Component Identification - Pilot and Direction Method

When specified, the following identification requirements shall apply for each layer specified in the applicable specification sheet:

a. Multi-Conductor Cables:
- 2 conductor - red and blue
- 3 conductor - red, blue, and white
- Others - red and blue conductors adjacent in each layer with remaining conductors white.

b. Multi-Pair Cables:
- Center Pair - red/blue
- Red/black and blue/black pairs adjacent in each layer with remaining pairs white/black.

c. Multi-Triad Cables:
- Each triad to be red/blue/white with the white wire in each triad numbered. In the case of jacketed triads, the jacket shall be numbered instead of the white component.

3.6.4 Conductor and Shield Continuity

Prior to shipment, one hundred percent of all finished cable shall be tested for continuity in accordance with 4.5.5. There shall be no indication of discontinuity in any of the component wires or shields, as applicable.

3.6.5 Identification of Finished Cable

The outer surface of the cable jacket shall be printed in accordance with the applicable specification sheet. The legend shall be printed at 12-inch *(305-mm)*, nominal, intervals in white ink on black jackets, or in an ink color providing suitable contrast on jackets with colors other than black. The mark shall be both durable and legible.

3.6.6 Insulation Resistance

When finished cable is tested in accordance with 4.5.9, the insulation resistance of the cable components shall meet the requirements of the applicable specification sheet.

3.6.7 Jacket Flaws

One hundred percent of finished shielded and jacketed cable shall pass the impulse test or the spark test specified in 4.5.11 using an impulse test voltage of 8.0 kV (peak) or a spark test voltage of 3.0 kV (rms). Testing shall be performed during the final winding of the cable on shipment spools or reels.

3.6.8 Jacket Thickness

Jacket thickness shall meet the requirements of the applicable specification sheet. The minimum jacket thickness, when tested in accordance with ASTM D 3032, Section 15, shall be no less than 80 percent of the specified nominal. Nominal jacket thickness is defined as half the difference between nominal cable diameter and the nominal diameter of the underlying layer.

3.6.9 Strength Member Breaking Stress

When tested in accordance with 4.5.14, strength members shall meet the requirements of the applicable specification sheet prior to cabling.

3.6.10 Surface Transfer Impedance

Where optimized or supershields are specified in the applicable specification sheet, the surface transfer impedance (shielding effectiveness) shall meet the requirements listed below (measured at a single frequency of 30 MHz), or the requirements of the applicable specification sheet for a swept frequency measurement, when tested per 4.5.15.

Maximum surface transfer impedance, in milliohms per meter at 30 MHz, shall be as follows when the diameter under the shield is:

Shield Construction	< 0.30 inch *(7.6 mm)*	≥ 0.30 inch *(7.6 mm)*
Single Optimized	100	50
Double Optimized	10	5
Supershielded (2 shields, 1 foil)	0.10	0.05
Double Supershielded (3 shields, 2 foils)	0.01	0.01

3.6.11 Voltage Withstand (Dielectric)

When tested in accordance with 4.5.16.1, the cable shall withstand the following voltages, except for coaxial cables which shall be tested in accordance with their own applicable specification sheet:

Connection	Voltage (rms)
Wire-to-wire	1500
Wire-to-shield	1500
Shield-to-shield (extruded jackets)	1000
Shield-to-shield (sealed tape jacket)	500
Shield-to-shield (unsealed tape jackets)	n/a

3.6.12 Workmanship

All details of workmanship shall be in accordance with high grade wire and cable manufacturing practices. The insulation and jacket shall be free of cracks, splits, irregularities, and imbedded foreign material.

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 examinations and tests shall be kept complete and available to the buyer as required.

4.2 CLASSIFICATION OF INSPECTIONS

The examinations and tests of materials and finished cable under this specification shall be divided into the following classifications:

Classification	Paragraph
Qualification inspection	4.3
Quality conformance inspection	4.4

4.3 QUALIFICATION INSPECTION

Qualification inspection shall consist of two samples as described in 4.3.1.

Sample 1 qualification inspection shall consist of the following tests from Table 1:

Accelerated Aging	Jacket Flaws
Color Codes and Methods	Jacket Shrinkage
Construction	Jacket Thickness
Finished Cable Diameter	Materials
Jacket Concentricity	Workmanship
Jacket Elongation and Tensile Strength	

Sample 2 qualification inspection shall consist of all of the tests specified in Table 2.

Requalification testing shall be performed any time changes in materials or processes occur that are deemed to have the potential for significantly altering the form, fit, function, or appearance of the product.

4.3.1 Qualification Samples

The following two samples are required for qualification.

Sample 1: A cable having a finished diameter of 0.350 to 0.650 inch *(8.9 to 17 mm)* and a jacket thickness of 0.040 ± 0.010 inch *(.76 to 1.3 mm)*. The underlying bundle must be shielded.

Sample 2: A sample of CJMS232-14.

4.3.2 Qualification Test Reports

When requested by the procuring activity, qualification test reports shall be supplied plainly identified with the specification title, revision and date, manufacturer's report number and date, and the manufacturer's name and address.

4.4 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection shall consist only of the examinations and tests listed in Table 1 identified as Group 1 or 2. Quality conformance inspection shall be performed on every lot of cable procured under this specification. Those tests that are of such a nature that they cannot be performed on the finished cable are performed at an appropriate stage during manufacture.

4.4.1 Sampling for Quality Conformance Inspection

Sampling for quality conformance inspection shall be in accordance with MIL-STD-1916 and the following:

4.4.1.1 Sample Unit (Group 1 Tests)

The sample unit for Group 1 tests, except for the Group 1 insulation resistance test, shall consist of a single piece of finished cable chosen at random from the inspection lot and shall be of sufficient length to permit all applicable examinations and tests.

4.4.1.1.1 *Sample Unit for Insulation Resistance Test (Group 1)*

The sample unit for the Group 1 insulation resistance test shall be a specimen at least 25 feet *(7.6 m)* in length selected at random from finished cable. It is optional whether the specimen is tested on the reel or removed from the lot for the test, provided the length of the specimen can be determined.

4.4.1.2 Acceptance for the Group 1 Tests

For Group 1 tests, including the insulation resistance test, the selected sample shall meet all applicable requirements of Table 1.

4.4.1.3 Sampling and Acceptance for the Group 2 Tests

The sample for the Group 2 tests shall be 100 percent of the finished cable, and every length of the cable shall be fully tested. Portions showing breakdown and ends or portions not subjected to these tests shall be removed and the remaining lengths tested until no failure occurs.

4.4.2 Nonconforming Inspection Lots

All lots found unacceptable under initial quality conformance inspection shall be reviewed and reworked in accordance with established internal procedures.

4.5 TEST METHODS

4.5.1 Accelerated Aging

Specimens of the finished cable jacket shall be prepared and conditioned in accordance with FED-STD-228, Method 4031, using an oven temperature of 225°C for 4 hours. Elongation and tensile strength shall be determined in accordance with 4.5.10.

4.5.2 Aging Stability

The finished wire insulation shall be conditioned in accordance with FED-STD-228, Method 4031, at 140 ± 3°C for 168 hours. Elongation and tensile strength shall be determined in accordance with AS4373, Method 705.

4.5.3 Certification of Materials

Prior to incorporation in a cable construction, incoming (raw) materials must meet internal procurement requirements that are not covered in this specification or the applicable specification sheet. Certificates of compliance shall be kept on file stating that the specified materials have been used and that they met all applicable requirements.

4.5.4 Characteristic Impedance

4.5.4.1 Characteristic Impedance - Method A

This method shall be used for cables whose nominal impedance is within 20 percent of Z_{ref}, where Z_{ref} is the impedance of the calibrated reference air line (CRAL). However, if the Time Domain Reflectometer (TDR) has the capability of displaying ohms at cursor, this method may also be used for cables whose nominal impedance falls outside 20 percent of the impedance of the CRAL.

4.5.4.1.1 *Method A - Specimen Preparation*

For coaxial cable, attach a suitable connector at one end of the cable. For twisted pairs, the measurement shall be made wire-to-wire. Designate one wire as the inner conductor and the other wire as the outer conductor and attach a suitable connector at one end.

4.5.4.1.2 *Method A - Apparatus*

The apparatus shall consist of a time domain reflectometer (TDR) with a maximum rise time of 150 picoseconds. A calibrated reference air line (CRAL) of suitable impedance and suitable connectors shall be used.

4.5.4.1.3 *Method A - Procedure*

Attach the CRAL to the TDR output. If the TDR displays ohms at cursor, follow the instrument manufacturer's procedure. If not, designate the resulting trace as Z_{ref} and adjust the horizontal magnifier control until Z_{ref} extends through at least six horizontal divisions. The sample cable shall then be attached and the resulting addition to Z_{ref} shall be designated as Z_c. With the cable attached, the Reflection Coefficient dial shall be adjusted so that Z_{ref} and Z_c are both on the graticule portion of the screen, but as far apart vertically as possible. Record the

setting on the dial as A_{RC}. Determine the vertical spacing between Z_{ref} and Z_c in vertical divisions and designate as ρ_u. If Z_{ref} is higher than Z_c, then ρ_u is negative. If Z_{ref} is lower than Z_c, then ρ_u is positive.

Define ρ as: $\rho = \rho_u * A_{RC}$

Characteristic impedance (Z_o) shall be determined from the following formula:

$$Z_o = Z_{ref} \frac{1 + \rho}{1 - \rho}$$

4.5.4.2 Characteristic Impedance - Method B

This method is appropriate for determination of the characteristic impedance of cables at specified frequencies of 1 MHz or higher.

4.5.4.2.1 *Method B - Procedure*

Using a 1 MHz bridge, determine the capacitance (C) in accordance with MIL-DTL-24640. The end of the specimen used to determine the capacitance shall then be shorted and the inductance (L) of the specimen determined using a 1 MHz bridge. Determination of the capacitance and inductance may also be made at other specified frequencies by use of a suitable bridge. For determining the characteristic impedance at frequencies higher than 1 MHz, the sample length should be shortened in order to minimize the effect of resonance. The characteristic impedance, at the specified frequency, shall be determined from the following relation:

$$Z_o = \sqrt{L/C}$$

Where:
Z_o = characteristic impedance in ohms
L = inductance in henries
C = capacitance in farads

For multi-pair cables, the capacitance (C) shall be the mutual capacitance (C_m).

4.5.5 Conductor and Shield Continuity

To establish continuity, 25 volts DC, maximum, shall be applied to both ends of each conductor and shield of the cable through an appropriate indicator, such as an ohmmeter, light, or buzzer. The test voltage may be applied to the conductors and shields individually, or in a series.

4.5.6 Conductor and Shield Resistance

The conductor or shield resistance of the finished cable shall be tested in accordance with FED-STD-228, Method 6021.

4.5.7 Examination of Product

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

4.5.8 Fluid Immersion

Specimens of the finished wire insulation, prepared in accordance with 4.5.10, shall be immersed in the fluids shown in Table 3 for 24 hours at the temperatures specified. The specimens shall then be removed, blotted to remove excess fluid, then suspended in air at room temperature for not less than 3.5 nor more than 4.5 hours. The elongation and tensile strength of the specimens shall then be determined in accordance with AS4373, Method 705.

TABLE 3. IMMERSION TEST FLUIDS

Test Fluid		Test Temperature
(a)	AMS1424, Deicing/Anti-Icing Fluid	50°C
(b)	Distilled Water	50°C
(c)	TT-I-735, Isopropyl Alcohol	23°C
(d)	MIL-PRF-17672, Hydraulic Fluid	50°C
(e)	MIL-PRF-23699, Lubricating Oil	50°C

Additionally, finished wire specimens of sufficient length to perform the 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 specified in Table 3 (using a separate specimen for each fluid) for 24 hours at the temperature specified. 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.

4.5.9 Insulation Resistance

Insulation resistance shall be measured on samples of finished cable at least 25 feet *(7.6 m)* in length. A DC potential between 200 and 500 volts shall be applied between each conductor or shield in the cable and all the other conductors and shields. The insulation resistance value shall be measured at any time after the application of the DC potential up to a maximum of 5 minutes. A direct-reading megohmmeter may also be used.

4.5.10 Jacket Elongation and Tensile Strength

Specimens of the finished cable jacket shall be carefully removed and tested for elongation and tensile strength in accordance with AS4373, Method 705, 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, unless otherwise specified in the applicable specification sheet. The thickness of the specimen shall be measured using a suitable micrometer.

4.5.11 Jacket Flaws

4.5.11.1 Impulse Test

Finished cable shall be tested in accordance with ASTM D 3032, Section 13, using the voltage specified in 3.6.7 with the shield grounded at one end or both ends. When specified in the contract or order, jacket failure, untested portions, or portions which have been exposed to fewer or more than the specified pulses may be marked by stripping the jacket or by any other suitable method of marking as specified in the contract in lieu of being cut out of the cable.

4.5.11.2 Spark Test

Finished cable shall be passed through a chain electrode spark test device using the voltage specified in 3.6.7 at a frequency of 60 or 3000 Hz. The shield shall be grounded at one or both ends. The electrode shall be of a suitable bead chain or fine mesh construction that will give intimate metallic contact with practically all of the cable surface. Electrode length and speed of specimen movement shall be such that the cable is subjected to the test voltage for a minimum of 0.2 second. Any portion showing jacket breakdown shall be cut out, including at least 2 inches *(51 mm)* of jacket on each side of the failure.

4.5.12 Jacket Shrinkage

A 12-inch *(305-mm)* specimen of cable shall be cut so that all components are flush at both ends. The specimen shall then be conditioned in an air-circulating oven at 150°C for 6 hours. At the end of this period, the specimen shall be removed from the oven and allowed to return to room temperature. Shrinkage of the jacket shall then be measured as the greatest distance which the jacket has receded from either end of the cable.

4.5.13 Secant Modulus

Specimens of the finished wire insulation shall be carefully removed and tested for secant modulus in accordance with ASTM D 882, using a 2-inch *(50-mm)* initial jaw separation and a jaw speed of 0.2 inch *(5 mm)* per minute. The pounds-force *(N)* at 2% elongation shall be recorded and used to calculate the Secant Modulus per the following equation.

$$\text{Secant Modulus (lbsf/in}^2\text{ at 2\%)} = \frac{\text{lbsf at 2\% elongation}}{\text{CSA x 0.02}}$$

Where: CSA = cross sectional area

4.5.14 Strength Member Breaking Stress

The breaking load of an entire strength member shall be tested by mounting a 10-inch *(254-mm)* sample in the tensile tester. Crosshead separation speed shall be 2 inches *(51 mm)* per minute. Special load-distributing grips designed for testing high-strength cords and yarns shall be used. The load required to break the sample shall not be less than that specified in the applicable specification sheet.

4.5.15 Surface Transfer Impedance

The surface transfer impedance of the overall shield of finished cable shall be tested in accordance with AS85485, 4.5.15.1 and 4.5.15.2 herein.

4.5.15.1 Specimen Preparation

The individual shields of shielded components, when present, shall be connected to the conductors, and the connected conductors and shields shall be "the conductor" as defined in AS85485, except on end "B" where only one conductor shall be "the conductor", with all other conductors and individual shields of shielded components floating. When a measurement at a discrete frequency is specified, the specimen length shall be 0.7 meter *(27.6 inches)*, otherwise the length shall be 1.0 meter *(39.4 inches)*.

4.5.15.2 Determination of Compliance

The value of Z_t, as determined from measurements made in accordance with the above, shall not exceed the maximum values of Z_t as specified in the applicable specification sheet in any of the following ways:

a. A single maximum value of Z_t may be specified at a discrete frequency or over a range of frequencies.

b. The maximum value of Z_t over a range of frequencies may be specified by a plot of the maximum value of Z_t versus frequency.

4.5.16 Voltage Withstand

Voltage withstand tests shall be made using an AC source with a frequency of 50 or 60 Hz. The voltage specified shall be applied for 15 to 30 seconds, unless otherwise specified.

4.5.16.1 Voltage Withstand (Dielectric)

Voltage withstand (dielectric) tests shall be performed upon finished cable as described in 4.5.16.1.1, 4.5.16.1.2, or 4.5.16.1.3 as appropriate, with the voltage specified in 3.6.11 or the specification sheet, as applicable.

4.5.16.1.1 *Wire-to-Wire*

Wire-to-wire tests shall be conducted by applying the specified voltage to each conductor in turn with all the other conductors grounded. Any shields present shall be left unconnected from any conductors and from each other except as described in 4.5.16.1.2.

4.5.16.1.2 *Wire-to-Shield*

Wire-to-shield tests shall be conducted by applying the specified voltage to each conductor in turn with all shields grounded. When the specified voltages for wire-to-wire tests and wire-to-shield tests are identical, the tests may be combined and the common specified voltage shall be applied to each conductor in turn with all other conductors and shields connected together and grounded.

4.5.16.1.3 *Shield-to-Shield*

Shield-to-shield tests shall be conducted by applying the specified voltage to each shield in turn with all other shields grounded.

4.5.16.2 Voltage Withstand (Post Environmental)

Voltage withstand (post environmental) tests on the outer jacket shall be performed after the specified conditioning. The finished cable shall be immersed in a 5-percent, by weight, solution of sodium chloride in water at room temperature for at least 1 hour and, while the cable is still immersed, a voltage of 2.5 kV (rms) shall be applied for 1 minute between all the conductors and shields, tied together, and the water bath which shall be grounded.

4.5.17 Weight

The weight of each lot of finished cable shall be determined by Procedure I (4.5.17.1). Lots failing to meet the weight requirement of the applicable specification sheet when tested in accordance with Procedure I shall be subjected to Procedure II (4.5.17.2). All spools or reels failing to meet the requirements of the applicable specification sheet when tested to Procedure II shall be rejected.

4.5.17.1 Procedure I

A length of cable, sufficient to produce a measured weight to at least 3 significant figures, shall be weighed and converted to the weight per unit length shown on the applicable specification sheet.

4.5.17.2 Procedure II

The net weight of the finished cable on each spool or reel shall be obtained by subtracting the tare weight of the spool or reel from the gross weight of the spool or reel containing the finished cable. The net weight of cable on each spool or reel shall be divided by the accurately determined length of finished cable on that spool or reel and the resultant figure converted to the weight per unit length shown on the applicable specification sheet. When wood or other moisture absorbent materials are used for spool or reel construction, weight determinations shall be made under substantially uniform conditions of relative humidity.

5. STANDARD PACKAGING

Unless otherwise specified (see 6.1), the following shall define the standard spooling and labeling requirements for cable furnished under this specification. Standard shipping tolerance on ordered quantity shall be ± 10 percent.

5.1 SPOOLING REQUIREMENTS

All layers of cable shall be wound on spools or reels (see 5.1.1) with sufficient tension to prevent shifting of layers and creation of crossovers within layers. Finished cable lengths shall be wound on spools or reels with all ends exposed. There shall be no more than 5 lengths per spool or reel and no length shall be less than 50 feet *(15 m)*.

5.1.1 Spools and Reels

Spools and reels shall be of a non-returnable type. Each spool and reel shall have an appropriate diameter for the respective cable size. In no case shall the barrel of the spool or reel have a diameter less than 12 times the nominal diameter of the finished cable. Spools and reels shall be suitably finished to prevent corrosion under typical storage and handling conditions. Loaded plastic spools shall not exceed 50 pounds *(23 kg)*. Loaded wooden reels shall have no weight restriction.

5.1.2 Containers

Unless otherwise specified (see 6.1), finished 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.

5.2 LABELING REQUIREMENTS

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

Manufacturer's 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 (see Section 5)

6.2 PRIMARY AND SECONDARY UNITS

Test requirements or parameters are originally developed using either English or Metric units. The original (primary) units are shown first with the converted values (secondary units) in parentheses. Secondary units are for reference only.

6.3 TRADEMARKS

Thermorad, Raychem, TE Connectivity, TE connectivity (logo), and TE (logo) are trademarks.