Raychem Wire and Cable
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PROCESS-CONTROLLED CABLE, ENHANCED, OPTIMIZED, AND TOUGHENED RADIATION-CROSSLINKED, MODIFIED ETFE*-JACKETED

*Ethylene-tetrafluoroethylene

1. SCOPE

1.1 SCOPE

This specification describes the characteristics, processes, and associated quality assurance provisions for process-controlled cable products manufactured with an enhanced, optimized, and toughened radiation-crosslinked, modified ETFE jacket material extruded over a shielded or unshielded 55PC primary wire or wires.

The characteristics, processes, and associated quality assurance provisions for the primary wire, prior to cabling, are specified in TE Connectivity/Raychem Specification 55PC.

1.2 DEFINITIONS

This section defines terms, not defined elsewhere, that are used in this specification and referenced documents.

Cable - Two or more wires twisted together, or one or more wires with an overall shield. Each wire, in this case, is termed a cable component.

Characteristic - Descriptive and/or measurable features or properties that define the part or process relative to design, performance, or process.

Conductor - The central, metallic component of an insulated wire, having a single (solid) strand, or multiple, twisted strands.

Jacket - An extruded layer of insulation applied over a cable. Its function is to provide mechanical and environmental protection rather than electrical properties.

SCD - The Specification Control Drawing describes a single wire or cable construction in one AWG size or a range of AWG sizes. It also contains requirements for certain characteristics.

Shield - A braided, or spiral, covering of round or flat metallic strands covering a wire or cable.

Target Value - The central value for a characteristic that reflects the ideal condition for the part or process.

Tolerance Limits - Values that represent limits of acceptability for a given characteristic.

Wire - A conductor having one or more concentric layers of extruded insulation.

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1.3 STANDARD INSULATION AND JACKET COLORS

Unless otherwise specified, finished cable products shall be supplied with the following colors:

1.3.1 Cable Jackets and Single-Conductor Cable

Cable jackets and the component wire of single-conductor cable shall be white in accordance with MIL-STD-104, Class 1 limits.

1.3.2 Multiconductor Cable (Two or More Components)

The insulation color for component wires of multiconductor cable shall be as follows:

Wire No.	Color	Wire No.	Color
1	Red	6	Violet
2	Blue	7	Orange
3	Yellow	8	Brown
4	Green	9	Pink
5	Black		

2. MANUFACTURING PROCESS FLOW

This section defines and outlines the essential processes, and their relationships, used in the manufacture of the cable described herein. Table 1 identifies the manufacturing process steps used for the basic product constructions offered under this specification. Table 2 identifies the product characteristics that are established and/or subsequently verified at these process steps (subsequent X's in the same row for a particular characteristic(s) indicate steps that have the potential to modify the initially established characteristic, thus the characteristic is rechecked).

Process Step Definitions:

EXTR. - The process of extruding a jacket onto a cable.

BEAM - The process of radiation crosslinking the jacket.

PID - Product Identification (marking or striping).

CABLE - Twisting two or more wires or components together.

BRAID - Application of a braided or spiral metallic shield.

SPOOL - Packaging of cable on final shipping spools, or in-process spooling for subsequent operations.

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TABLE 1. PRODUCT CONSTRUCTIONS VS. PROCESS STEPS

Construction	Incoming Material	Extr.	Beam	PID	Cable	Braid	Spool
Cable, no shield or jacket	Primary wire	---	---	---	X	---	opt
Jacketed Cable	Unshielded, unjacketed cable; Compound	X	X	opt	---	---	opt
Shielded Cable	Unshielded, unjacketed wire or cable; Shield strands	---	---	---	---	X	opt
Shielded and Jacketed Cable	Shielded wire or cable; Compound	X	X	opt	---	---	opt

X = Essential process step
opt = Optional process step depending on final disposition of product (e.g., finished product or in-process material to be used in another construction)
--- = Not applicable to product

TABLE 2. PRODUCT CHARACTERISTICS VS. PROCESS STEPS

Product Characteristics	Extr.	Beam	PID	Cable	Braid	Spool
Color	X	X	X	---	---	---
Jacket Dimensional Properties, Weight	X	---	---	---	---	---
Jacket Flaws	X	---	---	X	---	X
Workmanship	X	X	X	X	X	X
Crosslinked Verification, Jacket Elongation, Strippability	---	X	---	---	---	---
Identification of Product, Identification/Color Striping Durability	---	---	X	---	---	---
Cabling	---	---	---	X	---	---
Shield Construction and Coverage	---	---	---	---	X	---
Conductor and Shield Continuity, Dielectric Withstand	---	---	---	---	---	X

X = Essential process step
--- = Not applicable to product

3. REQUIREMENTS FOR CHARACTERISTICS

The requirements for cable characteristics are as specified in Table 3 and as detailed herein. The requirements for primary wire characteristics, prior to cabling, are as specified in TE Connectivity/Raychem Specification 55PC. The SCD and this specification define the requirements for the specified product. In the event of conflict between the two, the SCD takes precedence.

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TABLE 3. CABLE CHARACTERISTICS

Product Characteristics	Char.*	Requirement	Procedure
Blocking	Q	3.3.1	4.6.1
Cabling	P	3.2.1	4.6.4
Color	P	SCD and 1.3	4.6.4
Conductor and Shield Continuity	P100	3.2.2	WC 27500
Crosslinked Verification	P	3.2.3	4.6.3
Dielectric Withstand	P100	SCD and 3.2.4	WC 27500
Finished Cable Diameter	P	SCD	4.6.4
Flammability	Q	3.3.2	4.6.5
Flexure Endurance	Q	3.3.3	4.6.6
Fluid Immersion	Q	3.3.4	4.6.7
Fluoride Extraction	Q	SCD	4.6.8
Identification/Color Striping Durability	P	SCD and 3.2.5	AS22759
Identification of Product	P	SCD and 3.2.6	4.6.4
Jacket Concentricity	P	3.2.7	ASTM D 3032, Section 16
Jacket Construction	P	SCD	4.6.4
Jacket Elongation	P	3.2.8	4.6.9
Jacket Flaws	P100	SCD and 3.2.9	4.6.10
Jacket Material	M	3.1.3	4.6.2
Jacket Tensile Strength	Q	3.3.5	4.6.9
Jacket Thickness	P	SCD	4.6.4
Life Cycle	Q	3.3.6	4.6.11
Low Temperature-Cold Bend	Q	3.3.7	4.6.12
Primary Wire Materials	M	3.1.2	55PC
Pull Through	Q	3.3.8	4.6.13
Scrape Abrasion	Q	3.3.9	4.6.14
Shield Construction and Coverage	P	SCD and 3.2.10	WC 27500
Shield Material	M	SCD and 3.1.1	4.6.2 and 4.6.4
Shield Solderability (tin and silver shields only)	P	WC 27500	WC 27500
Strippability	P	WC 27500	4.6.4
Weight	P	SCD	4.6.15
Workmanship	P	3.2.11	4.6.4
Wraps	M	SCD and 3.1.4	4.6.2 and 4.6.4

*Characteristic Codes: M = Material Specific Characteristic (see 3.1)
P = Process Specific Characteristic (see 3.2)
P100 = Process Specific Characteristic, 100% tested (see 3.2)
Q = Qualification Specific Characteristic (see 3.3)

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3.1 MATERIAL SPECIFIC REQUIREMENTS

These characteristics, denoted by the code "M" in Table 3, are initially established and controlled by the incoming raw materials prior to the first process step (see Table 1). 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:

3.1.1 Shield Material

Shield strand material shall conform to the requirements specified in WC 27500 and the applicable SCD.

3.1.2 Primary Wire Materials

Primary wire materials, including insulating materials and conductor, shall conform to the requirements specified in TE Connectivity/Raychem Specification 55PC.

3.1.3 Jacket Material

The cable jacket material shall be an enhanced, optimized, and toughened radiation-crosslinked, extruded, modified ETFE.

3.1.4 Wraps

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

3.2 PROCESS SPECIFIC REQUIREMENTS

These characteristics, denoted by the codes "P" and "P100" in Table 3, are initially established and controlled by one particular process step (see Table 2). Unless otherwise specified, requirements for process specific characteristics shall be as follows:

3.2.1 Cabling

Cable components shall be twisted in a left-hand lay with a length of lay 8 to 16 times the cabled diameter. Cable components shall meet the requirements of the applicable component SCD prior to cabling.

3.2.2 Conductor and Shield Continuity

One hundred percent of all finished cable shall exhibit no loss of electrical continuity in the conductors or shields, as applicable.

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3.2.3 Crosslinked Verification

When finished cable is tested in accordance with 4.6.3, the jacket shall not crack or, if shielded and jacketed, fail dielectrically.

3.2.4 Dielectric Withstand

One hundred percent of finished cable shall pass the dielectric withstand test with an application time of 15 to 30 seconds, without breakdown, using the voltage specified in the applicable SCD.

3.2.5 Identification and Color Striping Durability

There shall be no discontinuity of identification mark or color stripe applied to the cable jacket after subjecting the mark or stripe to the number of cycles and the test load specified in the applicable SCD.

3.2.6 Identification of Product

When specified by the procuring activity, the finished cable shall be identified by a marking applied to the outer jacket. The identification shall consist of the appropriate mark as specified by the contract or the applicable SCD. The mark color shall be in accordance with MIL-STD-104, Class 1, and shall be contrasting to that of the marking surface. Identification shall be applied with the vertical axis of the printed characters parallel to the longitudinal axis of the 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 cable when the nominal diameter of the marking surface exceeds 0.050 inch *(1.3 mm)*.

3.2.7 Jacket Concentricity

The concentricity of the cable jacket shall be 70 percent, minimum.

3.2.8 Jacket Elongation

When finished cable is tested in accordance with 4.6.9, the elongation of the cable jacket shall be 50 percent, minimum.

3.2.9 Jacket Flaws

One hundred percent of finished shielded and jacketed cable shall pass the impulse dielectric test or the spark test specified in 4.6.10 using the voltage specified in the applicable SCD. Testing shall be performed during the final winding of the cable on shipment spools or reels.

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3.2.10 Shield Construction and Coverage

The optical coverage of braided or spiral shields shall be 85 percent, minimum. Braided shields shall have an angle of 18 to 40 degrees relative to the axis of the cable.

3.2.11 Workmanship

Workmanship of finished cable shall be uniform and free of external, or internal, physical or cosmetic irregularities.

3.3 QUALIFICATION SPECIFIC REQUIREMENTS

These characteristics, denoted by the code "Q" in Table 3, are a function of the combination of materials and processes used to produce a given cable construction. Following qualification, adherence to material specific and process specific requirements assures that the product will continue to meet the initial qualification specific requirements. Qualification specific requirements shall be as follows, when tested on 55OTE2212-20.

Conductor plating and/or shield plating substitutions may be allowed provided the cable construction is otherwise the same as specified.

3.3.1 Blocking

When finished cable is tested in accordance with 4.6.1, adjacent turns and layers of the cable shall not block. Blocking shall be defined as a transfer of material between adjacent surfaces when they are separated.

3.3.2 Flammability

When finished cable is tested in accordance with 4.6.5, 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.

3.3.3 Flexure Endurance

When finished cable is tested in accordance with 4.6.6, there shall be no loss of conductor or shield continuity, and no visible cracking of the jacket.

3.3.4 Fluid Immersion

When finished cable is tested in accordance with 4.6.7, the diameter increase shall be not more than 5 percent, there shall be no cracking of the jacket, and there shall be no dielectric breakdown of the jacket.

3.3.5 Jacket Tensile Strength

When finished cable is tested in accordance with 4.6.9, the tensile strength of the cable jacket shall be 5000 lbf/inch^2 *(34 N/mm^2)*, minimum.

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3.3.6 Life Cycle

When finished cable is tested in accordance with 4.6.11, there shall be no cracking of the jacket and no dielectric breakdown of the jacket.

3.3.7 Low Temperature-Cold Bend

When finished cable is tested in accordance with 4.6.12, there shall be no jacket cracking and no dielectric breakdown.

3.3.8 Pull Through

When finished cable is tested in accordance with 4.6.13, there shall be no visible signs of tear or rupturing of the jacket to expose the underlying shield or component wires, and there shall be no dielectric breakdown.

3.3.9 Scrape Abrasion

When finished cable is tested in accordance with 4.6.14, the cable shall meet the minimum average number of abrasion cycles for each temperature, after removing the highest and lowest result, as specified below.

Test Temperature	Minimum Average Number of Cycles to Failure
23 ± 2°C	5000
70 ± 2°C	3000
150 ± 2°C	100

4. QUALITY ASSURANCE PROVISIONS

4.1 QUALITY ASSURANCE SYSTEM

This section defines the Quality Assurance system that is used to assure that all products manufactured in accordance with this specification meet all applicable requirements.

4.2 QUALIFICATION INSPECTION

Qualification inspection shall consist of meeting all characteristics listed in Table 3. 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.

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4.3 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection shall consist of all material specific and process specific characteristics, represented by the codes "M", "P" and "P100" in Table 3. Quality conformance inspection shall be performed on every lot of cable procured under this specification, unless documentation of a statistical nature provides evidence that reduced inspection is warranted.

4.3.1 Sampling for Quality Conformance Inspection

MIL-STD-1916, inspection level S-3, AQL 1.5 percent, normal inspection, shall apply for all quality conformance testing. 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 cable of one part number or description, exclusive of color, 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 cable as offered for inspection.

4.3.1.3 Sample Unit

The sample unit for quality conformance inspection shall be of sufficient length to permit all applicable examinations and tests.

4.4 PROCESS CONTROL

Process control shall be maintained with the use of statistical process control and continuous improvement techniques.

4.4.1 Control Plan

The Control Plan describes the system for controlling the materials, construction, processes, and testing required for each cable product.

4.5 DOCUMENTATION

Test reports shall be prepared and kept in the Quality Control Department files for each manufactured lot of product. The results of the quality conformance inspection (see 4.3) shall be recorded in these test reports.

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4.6 TEST PROCEDURES

4.6.1 Blocking

Finished cable shall be tested in accordance with WC 27500 at 200 ± 3°C for 6 hours.

4.6.2 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 SCD. Certificates of compliance shall be kept on file stating that the specified materials have been used and that they met all applicable requirements.

4.6.3 Crosslinked Verification

Finished cable shall be tested in accordance with WC 27500, jacket style 23, except the oven exposure shall be 1 hour for quality conformance inspection and 6 hours for qualification inspection.

4.6.4 Examination of Product

Where requirements are not supported by specific test procedures, products shall be examined to determine conformance to this specification and the applicable SCD.

4.6.5 Flammability

4.6.5.1 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.

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4.6.5.2 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 applicable 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.

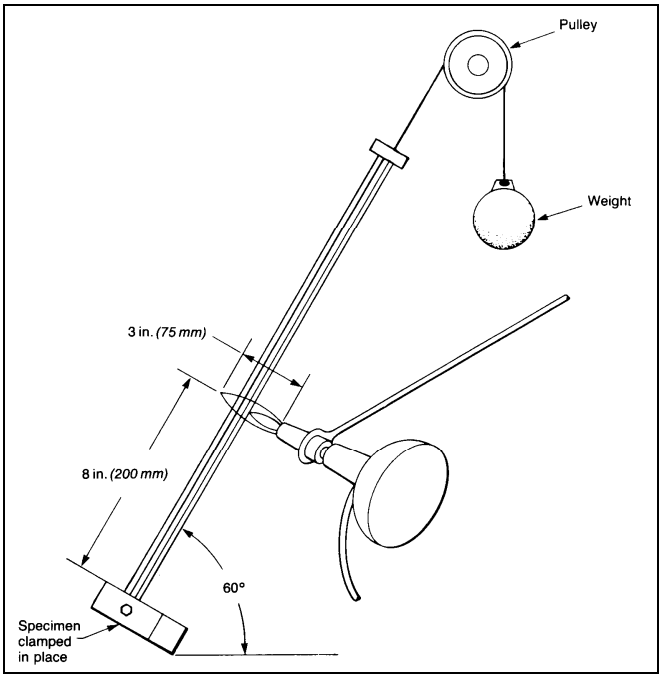

FIGURE 1. FLAMMABILITY TEST APPARATUS (shown without chamber)

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4.6.6 Flexure Endurance

Three 28-inch *(700-mm)* specimens of finished cable shall be tested. The test apparatus (Figure 2) shall contain a head fixture, consisting of a pair of mandrels and a cable clamp, which are affixed to a motor such that they can be driven to rotate about a point which is between, and equidistant from the centers of the two mandrels. Each of the mandrels shall have a diameter which is 10x the outer diameter of the cable specimen. The spacing between the mandrels shall be equal to the diameter of the specimen.

4.6.6.1 Specimen Preparation

One inch *(25 mm)* of jacket shall be stripped from each end of the cable specimen to expose the shield and conductor. One end of the cable shall be clamped into the head fixture such that the cable hangs vertically between the two mandrels. The cable shall pass between two guide rods, approximately 1 inch from the lower end of the cable, which shall prevent swinging during the test. The lower end of the cable shall be crimped to an appropriately sized ring tongue terminal. Be sure the terminal is attached to the braid only. A 3.00 ± 0.05 lbs *(1.36 ± 0.02 kg)* load shall be attached to the terminal to keep the cable taught.

4.6.6.2 Test Procedure

The cable, so installed into the test apparatus, shall be made to flex by rotation of the head fixture through 180 degree arc at a uniform rate of 18 ± 2 cycles per minute. One cycle shall comprise cable flexure from the vertical to 90 degrees left, then to 90 degrees right, and then return to vertical. After 200 cycles, the flexing shall be stopped. The specimen shall be visually inspected for cracks under 10x magnification, and the electrical continuity of the conductor and shield shall be confirmed using a continuity tester.

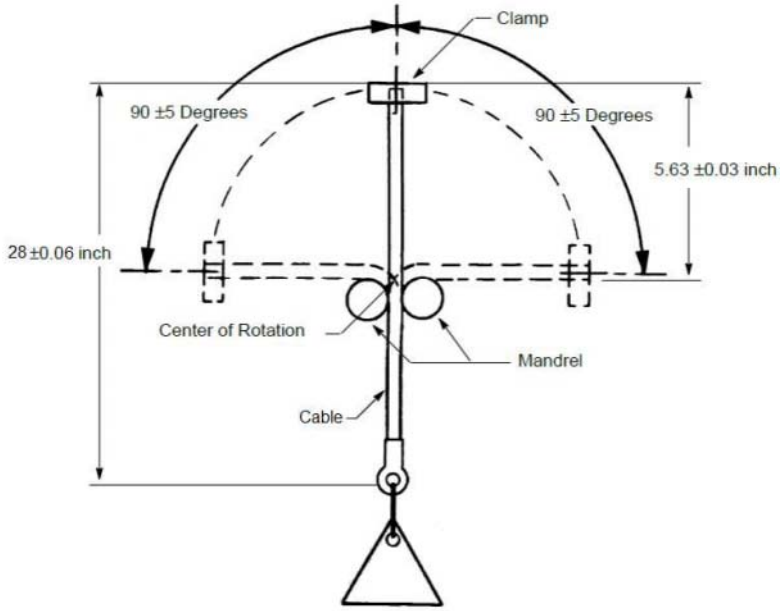

FIGURE 2. FLEXURE ENDURANCE TEST APPARATUS

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4.6.7 Fluid Immersion

Finished cable shall be tested in accordance with AS4373, Method 601, using each of the fluids specified with the following exceptions:

a) During sample preparation, each sample shall be marked at one end, and have its diameter measured at three positions along its length at distances of 8-inch, 12-inch, and 16-inch from this end. The post-immersion diameter measurement shall take place at the same marked positions as pre-immersion, and these pairs of before and after measurements shall be used for comparison.

b) The post-immersion, bend test shall be conducted according to AS4373, Method 712, using a 3.0 lb *(1.4 kg)* weight attached to the sample, and a mandrel whose diameter is 50x the specified maximum diameter of the cable. For each specimen, any observed separation or delamination of layers shall be recorded.

c) The post-bend, voltage withstand test shall be conducted in accordance with WC 27500 using a 1-hour immersion in a solution of 3 ± 0.5 percent by weight NaCl in distilled water followed by 1.0 kV applied for 1.0 minutes between the shield and water.

4.6.8 Fluoride Extraction

Approximately 0.5 gram of jacket material shall be removed from the finished cable specimen, cut into 3-inch *(76-mm)* lengths and weighed to the nearest milligram. A polystyrene test tube (without its cap) shall also be weighed to the nearest 0.1 gram. After filling with approximately 14 ml of distilled water, the polystyrene test tube shall be reweighed. The jacket material specimen shall then be placed into the test tube, making sure that the specimen is fully submerged, and the test tube cap is tightly attached. The test tube shall then be partially immersed in a 70 ± 2°C water bath so that the water levels of the bath and the test tube are equal. The test tube shall be so conditioned for 168 hours with the set-up being periodically checked to make sure that the specimen is still submerged. After conditioning, the test tube shall be removed from the bath and allowed to cool. The cap shall then be removed from the test tube, and the tube, water and specimen shall be weighed to determine the water weight loss. If the water loss is more than 0.5 gram, the test shall be rerun. Otherwise, 5 ml of the test tube water shall be analyzed for fluoride ion content using an Ion Chromatograph. The fluoride ion content shall be reported in ppm of water and shall not exceed the amount specified in the applicable SCD. A blank test in accordance with 4.6.8.1 should also be conducted in case the result is needed for calculation purposes.

4.6.8.1 Blank Test

A blank test follows the same procedure as 4.6.8 except that a specimen is not included. What is tested is the distilled water and the specimen tube. Ideally, there are no fluoride ions in either the test tube or the distilled water such that the result for the blank test would be zero. However, there may be a low non-zero result (i.e. 0.005 ppm). If this occurs, the ppm of fluoride for the blank test must be subtracted from the ppm of fluoride obtained from the specimen. A blank test also performs the same function as a calibration as it can indicate a

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problem with the test procedure. For example, should the blank test produce a result of 15 ppm of fluoride, this would be an indication that the ion chromatograph is not functioning correctly, tap water was used in place of distilled water, etc.

4.6.8.2 Calculation

If necessary, the blank test result shall be subtracted from the specimen result to obtain the net fluoride ion content (ppm). The fluoride ion content of the jacket weight shall then be calculated as follows:

$$\text{F ion} = \frac{\text{Net F ion (ppm) x Original water weight}}{\text{Original specimen weight}}$$

4.6.9 Jacket Elongation and Tensile Strength

Specimens of the cable jacket shall be carefully removed from the cable and tested for tensile strength and elongation in accordance with ASTM D 3032, Section 17, 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.

4.6.10 Jacket Flaws

4.6.10.1 Impulse Dielectric Test

Finished cable shall be tested in accordance with ASTM D 3032, Section 13, at the voltage specified in the applicable SCD 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.

4.6.10.2 Spark Test

Finished cable shall be passed through a chain electrode spark test device using the voltage specified in the applicable SCD 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 breakdown shall be cut out, including at least 2 inches *(51 mm)* of jacket on each side of the failure.

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4.6.11 Life Cycle

Finished cable shall be tested in accordance with the crosslinked verification test specified in WC 27500, with the following exceptions:

a) Three cable specimens shall be tested.
b) Each end of the cable specimen shall be loaded with 2.5 lbs *(1.1 kg)* weights.
c) The mandrel size shall be 40x the finished cable diameter.
d) The temperature and duration of the oven exposure shall be 230 ± 3°C for 500 hours.

4.6.12 Low Temperature-Cold Bend

Finished cable shall be tested in accordance with WC 27500, jacket style 23.

4.6.13 Pull Through

4.6.13.1 Specimen Preparation

Three 40-inch *(1-m)* finished cable samples shall be tested.

4.6.13.2 Test Apparatus

The test apparatus (Figure 3) shall consist of a fixture through which the cable shall travel horizontally during the test. At the center of the fixture shall be a box section, with openings to suit cable entry and exit on opposite sides. The lower surface of the box section through which the cable passes shall be grooved with a suitable radius to guide the cable without any transverse movement. The weight piece with the load mounted shall rest in the box section without any lateral movement. The lower edge of the weight piece shall have a provision for attaching a needle. The needle used shall be a horizontally mounted, polished, nickel coated steel sewing needle or equivalent with a diameter of 0.02 inch ± 0.0004 inch *(0.5 mm ± 0.01 mm)*. The test shall be conducted at room temperature 23 °C ± 2 °C *(72 °F ± 5 °F)*. The test fixture shall be mounted into the lower jaw of a conventional vertically arranged tensile test apparatus. The upper jaw shall be positioned approximately 2 inches *(5 cm)* above the fixture. Be sure to confirm the cleanliness of the needle apparatus prior to starting the test. One end of the cable specimen shall be fixed into the upper jaw of the tensile test apparatus and then laced through the two cable guides on the fixture such that the cable will pass horizontally through the box section. From the other end of the cable, a 2 lb *(1 kg)* weight shall be suspended that is sufficient to cause the cable to be kept taught while in the apparatus. The total load applied to the sample shall be 8.8 lb *(4 kg)*. The weight piece shall be carefully positioned onto the cable in the box section of the fixture.

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4.6.13.3 Test Procedure

Conduct the test with the upper jaw raised to a speed of 20 inch/min *(500 mm/min)* until the weight at the other end of the cable has been raised by approximately 12 inch (± 1 inch) *(300 mm ± 25 mm)*. The start and end of the test area, where the weight piece has contacted the specimen, shall be clearly marked. The needle shall be changed after each test. The test specimen shall be visually assessed for damage, and shall then be subjected to the voltage withstand test in accordance with WC 27500 4.3.7 using a 1-hour immersion in a solution of 3 ± 0.5 percent by weight NaCl in distilled water followed by 1.0 kV applied for 1.0 minute between the shield and water. Be sure to immerse the full marked test area.

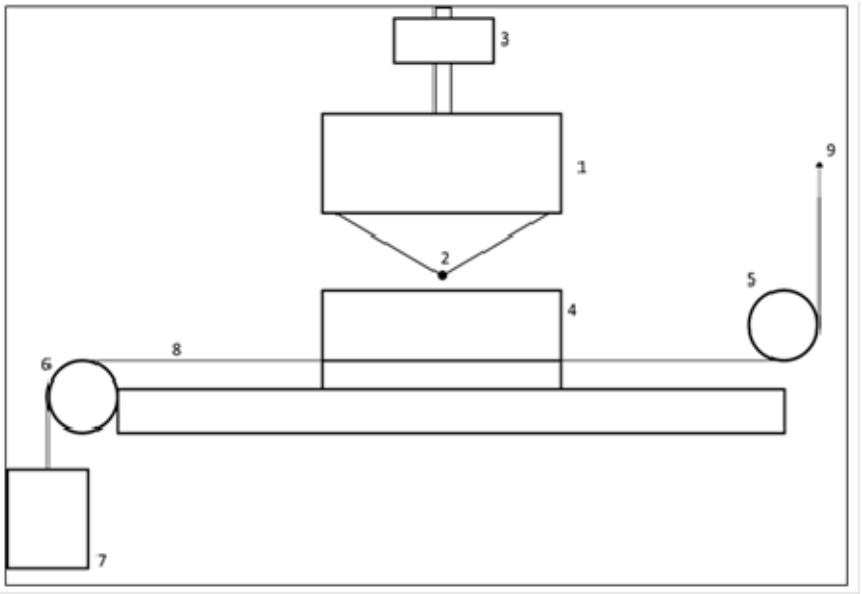

FIGURE 3. PULL THROUGH TEST APPARATUS

Key:

1. Weight piece
2. Needle holder/needle
3. Mass
4. Box section
5. Roller
6. Roller
7. Straightening load
8. Cable test specimen
9. Cable to tensiometer

4.6.14 Scrape Abrasion

Finished cable shall be tested in accordance with AS4373, Method 301, with the following modifications:

a) The test fixture shall contain a thermocouple located within one inch of the cable abrasion site, and a second thermocouple embedded into the center of the sample holding block. These thermocouples shall be used to measure the temperature of the sample and equipment during elevated temperature testing.

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b) Before installing the cable specimen into the test fixture, the specimen shall be marked at each of ten abrasion locations along its length. The distance between marked areas shall not be less than 4 inches *(102 mm)* and shall be sufficient to ensure that the ends of the sample lie outside the test chamber for electrical connection. The position of each subsequent test location shall be incrementally rotated 90° clockwise about the specimen axis.

c) For elevated temperature testing, the cable specimen shall be cut into individual test samples to avoid thermal conduction between adjacent test areas. In this case, the position of each test area (angle and separation) shall be marked prior to cutting. Additionally, for elevated temperature testing, cable specimens shall not be installed into the test fixture until the sample holder has reached the prescribed test temperature and then stabilized for 5 minutes. Each specimen shall be allowed to stabilize for 5 minutes prior to applying the test load. Once the test load is applied, begin the oscillation after no more than a 5 second delay and then allow the test to continue as per AS4373, Method 301.

4.6.15 Weight

The weight of each lot of finished cable shall be determined by Procedure I (4.6.15.1). Lots failing to meet the weight requirement of the applicable SCD when tested in accordance with Procedure I shall be subjected to Procedure II (4.6.15.2). All spools or reels failing to meet the requirements of the applicable SCD when tested to Procedure II shall be rejected.

4.6.15.1 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 SCD.

4.6.15.2 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 SCD. 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.

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5. STANDARD PACKAGING

Unless otherwise specified (see 7.1), 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 nonreturnable 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 3.5 inches *(89 mm)*. 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 7.1), 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

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6. APPLICABLE DOCUMENTS

6.1 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.

6.1.1 Department of Defense

SPECIFICATIONS

Federal

UU-T-450 Tissue, Facial

STANDARDS

Military

MIL-STD-104 Limits for Electrical Insulation Color

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, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094; or at http://assist.daps.dla.mil/quicksearch/.)

6.2 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.

6.2.1 American Society for Testing and Materials (ASTM)

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.)

6.2.2 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.)

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6.2.3 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 17th Street, Rosslyn, VA 22209; or at www.nema.org.)

6.2.4 Society of Automotive Engineers (SAE)

AS4373 Test Methods for Insulated Electric Wire

AS22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

(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.)

6.2.5 TE Connectivity/Raychem

Specification 55PC Process-Controlled Wire and Cable, Radiation-Crosslinked, Modified ETFE-Insulated

(Copies of TE Connectivity/Raychem documents may be obtained from TE Connectivity, 501 Oakside Avenue, Redwood City, CA 94063-3800.)

7. NOTES

7.1 ORDERING DATA

Procurement documents should specify the following:

a. Title, number, and revision of this specification
b. Applicable SCD part number and color code (see 1.3)
c. Quantity
d. Special preparation for delivery requirements, if applicable (see Section 5)

7.2 METRIC UNITS

Metric units (where shown in parentheses) are for information only.

7.3 TRADEMARKS

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