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Standard for Control, Thermocouple Extension, and Instrumentation Cables

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Foreword

The *Standard for Control, Thermocouple Extension and Instrumentation Cables*, ICEA S-73-532, NEMA WC 57-2003, was developed by the Insulated Cable Engineers Association, Inc. (ICEA) and approved by the National Electrical Manufacturers Association (NEMA). Unless otherwise noted as Authorized Engineering Information, this Standards Publication has been approved by NEMA as a NEMA Standard.

ICEA/NEMA Standards are adopted in the public interest and are designed to eliminate misunderstanding between the manufacturer and the user and to assist users in selecting and obtaining the proper product for their particular needs. Existence of an ICEA/NEMA Standard does not in any respect preclude the manufacture or use of products not conforming to the standard. The user of this standard is cautioned to observe any health or safety regulations and rules relative to the manufacture and use of cable made in conformity with this standard.

This standard does not specify any specific frequencies for sampling for test purposes, cable products, or components. One program of sampling frequencies is given in Publication ICEA T-26-465/NEMA WC 54-2000.

Requests for interpretation of this standard must be submitted in writing to the Insulated Cable Engineers Association, Inc., PO Box 1568, Carrollton, GA 30112. An official written interpretation will be provided, once approved by ICEA and NEMA. Suggestions for improvements gained in the use of this publication will be welcomed by the Association.

Scope

This standard applies to materials, construction, and testing of multiconductor control, thermocouple extension, and instrumentation cables rated up to and including 125°C. Control cables are multiconductor cables that convey electrical signals used for monitoring or controlling electrical power systems and their associated processes. Control cables convey signals between devices interfaced directly with the electrical power system, such as current transformers, potential transformers, relays, switches, and meters. Instrumentation cables and thermocouple extensions are multiconductor cables that convey low energy electrical signals (circuits which are inherently power limited) used for monitoring or controlling electrical power systems and their associated processes. Instrumentation cables and thermocouple extensions convey signals from process monitors to process analyzers (usually electronic equipment) and from the analyzers to control equipment in the electric power system. Construction details and test requirements for cables rated above 125°C can be found in the NEMA HP-100 series of standards.

Section 1 GENERAL

1.1 GENERAL INFORMATION

This publication is arranged so that cables can be designated and selected in numerous constructions for a broad range of installation and service conditions. Parts 2 through 4 cover the major components of the cables:

Part 2—Conductors

Part 3—Insulations

Part 4—Shieldings and Coverings

Each of these parts designates the materials, material characteristics, dimensions, and tests applicable to the particular component.

Part 5 covers assembly, cabling, and identification of the individual insulated conductors, with or without associated shields.

Part 6 describes some, but not all, of the test methods applicable for the component materials and completed cables. Other test methods are found in ICEA T-27-581/NEMA WC 53.

Part 7 contains special constructions.

Part 8 contains appendices with reference data such as abbreviations, definitions, material characteristics, application, and installation information. Particular attention is called to Appendix A, which gives the title and date of industry standards and other publications referenced herein.

In classifying components in this standard, the following definitions apply:

metal tape: A relatively thin and narrow metal strip that includes straps and ribbons.

jacket: A polymeric (nonmetallic) protective covering applied over the insulation, core, sheath, or armor of a cable, e.g. a PVC jacket. A jacket is not impervious to water or other liquids.

sheath: A metallic covering, impervious to water and other liquids, applied over the insulation, core, or jacket of a cable, e.g. a lead sheath.

Conductor sizes are expressed by American Wire Gage (AWG). Steel armor wire sizes are expressed by Birmingham Wire Gage (BWG).

Temperatures are expressed in degrees Celsius. The Fahrenheit equivalents of degrees Celsius can be calculated by the equation $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$. Room temperature is defined as a temperature from 20°C to 28°C inclusive.

Mass is expressed in grams. The ounce equivalents to grams can be calculated by dividing the number of grams by 28.35. Other values are expressed in non-metric units commonly used in North America.

To convert values in non-metric units to the approximate values in appropriate metric units, multipliers given in the following table should be used:

From	To	Multiplier
inches (in.)	millimeters (mm)	25.4
ohms per 1000 ft (Ω /1000 ft)	milliohms per meter (m Ω /m)	3.28
square inch (in. ²)	square millimeter (mm ²)	645
circular mil (cmil)	square millimeter (mm ²)	5.07×10^{-4}
pounds per square inch (psi)	megapascals (Mpa)	6.89×10^{-3}
gigaohms-1000 ft (G Ω -1000 ft)	gigaohms-meter (G Ω -m)	305

1.2 INFORMATION TO BE SUPPLIED BY PURCHASER

When requesting proposals from manufacturers, the prospective purchaser should describe the cable by reference to pertinent parts of this standard. To help avoid misunderstandings and possible misapplication of cable, he or she should also provide pertinent information concerning the intended application.

Section 2 CONDUCTORS

2.1 GENERAL

Copper conductor requirements shall be determined in accordance with the procedures or methods designated by the referenced ASTM standards (see Appendix A) unless otherwise specified in 2.3 of this standard. Thermocouple extension wire conductor requirements are given in 2.4 of this standard.

The following technical information on typical conductors may be found in Appendix B:

- a. Approximate diameters of stranded copper conductors.
- b. Approximate weights of copper conductors.

2.2 WIRES, PHYSICAL AND ELECTRIC PROPERTIES

The wires used in conductors shall be copper in accordance with 2.3.

2.3 COPPER CONDUCTORS

2.3.1 Wires

Copper wires shall meet the chemical requirements of ASTM B 5 and either 2.3.1.1 or 2.3.1.2.

2.3.1.1 Soft or annealed copper wires intended for a stranded conductor shall meet the elongation, finish, and coating continuity requirements of one of the following:

- a. ASTM B 3 for uncoated wires or
- b. ASTM B 33 for tin coated wires.

2.3.1.2 Copper wires, if removed from a concentric lay stranded conductor, annealed after stranding, shall meet the elongation requirements of ASTM B 8, Sections 7.4, 7.5, and 7.6.

2.3.2 Solid Conductors

A solid copper conductor shall consist of a single round wire meeting the requirements given in 2.3.1.1.

2.3.3 Stranded Conductors

Stranded conductors shall consist of seven wires or 19 wires individually meeting the appropriate requirements of 2.3.1.

Diameters of individual wires in stranded conductors are not specified. The requirements for lay and joints shall be in accordance with ASTM B8 for concentric lay Class B or Class C stranded copper conductors except that a splice is acceptable in stranded conductors as a whole if the splice (butt splice) is made by machine brazing or welding such that the resulting solid section of the stranded conductor is not longer than $\frac{1}{2}$ in. or 13 mm, the splice does not increase the diameter of the conductor, there are no sharp points, and the distance between splices in a single conductor does not average less than 3000 ft or 915 m in any reel length of that single insulated conductor.

2.3.4 Conductor DC Resistance per Unit Length

The DC resistance per unit length of each conductor in a production or shipping length of completed cable shall not exceed the value determined from the schedule of maximum DC resistances specified in

Table 2-1 when using the appropriate nominal value from Table 2-2. The DC resistance shall be determined in accordance with 2.3.4.1 or 2.3.4.2.

When the resistance is measured on a single conductor sample taken from a multiple conductor cable or when the resistance is calculated, the appropriate maximum resistance value specified for the single conductor shall apply.

Table 2-1
SCHEDULE FOR ESTABLISHING MAXIMUM DC RESISTANCE PER UNIT
LENGTH OF COMPLETED CABLE

Cable Type	Maximum DC Resistance
Single Conductor*	Table 2-2 Value Plus 2% ($R_{\max} = R \times 1.02$)
Multiple Conductor Cables	Table 2-2 Value Plus 2% plus one of the following 2%-One layer of Conductors ($R_{\max} = R \times 1.02 \times 1.02$) 3%-More than one layer of Conductors ($R_{\max} = R \times 1.02 \times 1.03$) 4%-Pairs or other precabled Units ($R_{\max} = R \times 1.02 \times 1.04$) 5%-More than one layer of Pairs or other precabled Units ($R_{\max} = R \times 1.02 \times 1.05$)

*Applied to a sample only, see 2.3.4.

2.3.4.1 Direct Measurement of DC Resistance Per Unit Length

The DC resistance per unit length shall be determined by DC resistance measurements made in accordance with ICEA T-27-581/NEMA WC 53 to an accuracy of 2% or better.

If measurements are made at a temperature other than 25°C, the measured value shall be converted to resistance at 25°C by using the methods specified in ICEA T-27-581/NEMA WC 53.

If verification is required for the DC resistance measurement made on an entire length of completed cable, a sample at least 1 ft long shall be cut from that reel length, and the DC resistance of each conductor shall be measured using a Kelvin-type bridge or a potentiometer.

Table 2-2
NOMINAL DC RESISTANCE IN OHMS PER 1000 FT AT 25°C OF SOLID AND CONCENTRIC LAY STRANDED COPPER CONDUCTORS

Conductor Size, AWG	Stranded Copper				
	Solid Copper		Uncoated		
	Uncoated	Coated	Class B and C	Class B	Class C
22	16.5	17.2	16.7	17.9	18.1
20	10.3	10.7	10.5	11.1	11.3
19	8.20	8.52	8.33	8.83	8.96
18	6.51	6.76	6.67	7.07	7.14
17	5.15	5.35	5.21	5.52	5.64
16	4.10	4.26	4.18	4.43	4.44
14	2.57	2.67	2.63	2.73	2.79
13	2.04	2.12	2.08	2.16	2.21
12	1.62	1.68	1.66	1.72	1.75
11	1.29	1.34	1.31	1.36	1.36
10	1.02	1.06	1.04	1.08	1.08
9	0.808	0.831	0.825	0.856	0.856

2.3.4.2 Calculation of DC Resistance Per Unit Length

The DC resistance per unit length at 25°C shall be calculated using the following formula:

$$R = 10^3 K \rho / A$$

Where:

R = Conductor resistance in $\Omega/1000$ ft

K = Weight and resistance increment factor

ρ = Volume resistivity in $\Omega\text{cmil/ft}$

A = Cross-sectional area of conductor in cmil

- Volume resistivity (ρ) of the conductor material shall be determined in accordance with ASTM B 193 using round wires.
- Cross-sectional area (A) of solid- and concentric-lay stranded conductors shall be determined in accordance with ICEA T-27-581/NEMA WC 53.
- Weight and resistance increment factor (K) shall be taken as 1.02, or it shall be calculated in accordance with ASTM B 8.

2.3.5 Conductor Diameter

The diameter of a solid conductor shall be measured in accordance with ICEA T-27-581/NEMA WC 53. The diameter of a solid conductor shall not differ from the nominal values shown in Table 2-3 by more than $\pm 5\%$. * No diameter requirements apply to stranded conductors.

*The 5% diameter tolerance for solid conductors is provided to enable a designer of connectors to determine the range of conductor sizes that will fit a particular connector; however, a conductor meeting the minimum diameter requirement does not necessarily meet the requirement for maximum DC resistance specified in 2.3.4.

Table 2-3
NOMINAL DIAMETERS FOR SOLID COPPER CONDUCTORS

Conductor Size, AWG	Solid Diameters, in.
22	0.0253
20	0.0320
19	0.0359
18	0.0403
17	0.0453
16	0.0508
14	0.0641
13	0.0720
12	0.0808
11	0.0907
10	0.1019
9	0.1144

2.4 CONDUCTORS FOR THERMOCOUPLE EXTENSION WIRES

2.4.1 Conductor Material

The conductor elements shall be in accordance with ANSI ISA MC96.1 and Table 2-4 for the listed types of thermocouple extension wires.

2.4.2 Size and Diameter

Conductors shall be solid or stranded. Stranded conductors shall be composed of seven wires. Applicable sizes and nominal diameters shall be in accordance with Table 2-5.

**Table 2-4
EXTENSION WIRE ELEMENTS**

Type	Extension Wire	Conductor Material**
T	TX	TPX Copper TNX Constantan
J	JX	JPX Iron JNX Constantan
E	EX	EPX Chromel*, Tophel*, T-1* ENX Constantan
K	KX	KPX Chromel*, Tophel*, T-1* KNX Alumel*, Nial*, T-2*
R or S	SX	SPX Copper SNX Copper Nickel Alloy
B	BX	BPX Copper BNX Copper

* Trade Name

** Materials are listed as typical of those commercially available at present, and their listing implies no endorsement by this standard.

**Table 2-5
NOMINAL DIAMETERS OF THERMOCOUPLE WIRES**

Conductor Size AWG	Solid Conductor in.	Stranded	
		Individual Wire in.	Stranded Conductor in.
20	0.0320	0.0126	0.038
18	0.0403	0.0159	0.048
16	0.0508	0.0201	0.060

2.4.3 Direct-Current (DC) Resistance of Conductors

The approximate DC resistance at 20°C of thermocouple conductor materials is given in Table 2-6. If specific maximum or minimum limitations on DC resistance are required, such limitations shall be specified by the purchaser.

2.4.4 Temperature Limits of Conductors

The temperature limitations for use of the various thermocouple extension wire conductors shall be in accordance with ANSI ISA MC96.1, Section 3.

2.4.5 Limits of Error of Conductors

The limits of error for the various thermocouple extension wire conductors shall be in accordance with ANSI MC96.1, Section 3.

Table 2-6
NOMINAL DIRECT CURRENT RESISTANCE IN OHMS PER 1000 FT
AT 20°C OF SOLID OR STRANDED THERMOCOUPLE CONDUCTORS

Conductor Material						
Size (AWG)	KNX	EPX KPX	ENX JNX TNX	TPX SPX BPX BNX	SN SNX	JPX
20	173	415	287	10.1	27.4	69.9
18	111	266	184	6.39	17.5	44.6
16	68.3	164	113	4.02	10.8	27.6

Section 3 INSULATIONS

3.1 GENERAL

The following insulations for control, thermocouple extension and instrumentation cable shall be an extruded dielectric material meeting the dimensional, electrical, and physical requirements specified in the following paragraphs. It shall be suitable for use in the locations and at the temperatures specified in 3.3. The insulation shall be applied directly to the surface of the conductor or conductor separator if used and shall fit tightly to that surface.

3.2 MATERIALS

The insulation shall consist of one of the materials shown below:

- Crosslinked Polyethylene (XLPE), Type I
- Crosslinked Polyethylene (XLPE), Type II
- Ethylene Propylene Rubber (EP), Type I
- Ethylene Propylene Rubber (EP), Type II
- Silicone Rubber (SR)
- Chlorosulfonated Polyethylene (CSPE)*
- Polyvinyl Chloride (PVC)
- Polyvinyl Chloride/Nylon (PVC/Nylon)
- Polyethylene (PE)
- Composite EP/CSPE or EP/Neoprene (CR)
- Styrene Butadiene Rubber (SBR)
- Thermoplastic Elastomer (TPE), Type I
- Thermoplastic Elastomer (TPE), Type II

*Also known as Chlorosulfonyl Polyethylene (CSM)

3.3 THICKNESS

The minimum average thickness shall not be less than as specified in Table 3-1 or Table 3-1M. The minimum thickness at any one point shall not be less than 90% of the specified value.

3.3.1 SR

0.005 in. (0.127 mm) of the specified average SR insulation thickness may be replaced by not less than 0.005 in. (0.127 mm) of a closely woven and impregnated glass braid.

3.3.2 PE

For cables rated 600 V, 0.010 in. (0.254 mm) of the specified average PE insulation thickness may be replaced by not less than 0.010 in. (0.254 mm) of PVC. For cables rated 1000 V, 0.015 in. (0.381 mm) of the specified average PE insulation may be replaced with not less than 0.015 in. (0.381 mm) of PVC. The PVC shall comply with the physical and aging requirements of Table 3-2. For all voltages given in Table 3-1 (Table 3-1 M), 0.004 in. (0.102 mm) of the average PE insulation thickness may be replaced by

not less than 0.004 in. (0.102 mm) of nylon except that in no case shall the thickness of the PE be less than 0.015 in. (0.381 mm).

For 300 volt rated cable, the insulation thickness may be reduced by 0.005 in. (0.127 mm) provided that the tensile strength of the insulation is 2000 psi minimum.

3.3.3 PVC

For all voltages given in Table 3-1 (Table 3-1 M), 0.004 in. (0.102 mm) of the specified average PVC insulation thickness may be replaced by not less than 0.004 in. (0.102 mm) of nylon.

**Table 3-1
INSULATION THICKNESS IN INCHES**

Conductor Size, AWG	XLPE Types I and II	EP Types I and II	SR	SBR and CSPE	PVC	PE	TPE Types I and II	Composite EP/CSPE or EP/CR	PVC/Nylon
300 V									
22-19	0.015	0.020	0.025	0.025	0.020	0.015	0.020	0.020/0.010	---
18	0.015	0.020	0.025	0.025	0.025	0.020	0.020	0.020/0.010	---
16	0.015	0.020	0.025	0.025	0.025	0.020	0.020	0.020/0.010	---
14-9	0.020	0.025	0.030	0.030	0.025	0.020	0.020	0.020/0.010	---
600 V									
20-19	0.025	0.025	0.030	0.030	0.025	0.025	0.025	0.020/0.010	---
18-16	0.025	0.025	0.030	0.030	0.030	0.025	0.025	0.020/0.010	0.015/0.004
14-11	0.030	0.030	0.045	0.045	0.045	0.030	0.030	0.020/0.010	0.015/0.004
10-9	0.030	0.030	0.045	0.045	0.045	0.030	0.030	0.020/0.010	0.020/0.004
1000 V (Control Cables Only)									
16	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.030/0.015	---
14-9	0.045	0.045	0.060	0.060	0.060	0.045	0.045	0.030/0.015	---

Table 3-1 M
INSULATION THICKNESS IN MILLIMETERS

Conductor Size, AWG	XLPE Types I and II	EP Types I and II	SR	SBR and CSPE	PVC	PE	TPE Types I and II	Composite EP/CSPE or EP/CR	PVC/Nylon
300 V									
22-19	0.381	0.510	0.635	0.635	0.381	0.381	0.510	0.510/0.254	---
18	0.381	0.510	0.635	0.635	0.510	0.510	0.510	0.510/0.254	---
16	0.381	0.510	0.635	0.635	0.510	0.510	0.510	0.510/0.254	---
14-9	0.510	0.635	0.762	0.762	0.510	0.510	0.510	0.510/0.254	---
600 V									
20-19	0.635	0.635	0.762	0.762	0.635	0.635	0.635	0.510/0.254	---
18-16	0.635	0.635	0.762	0.762	0.762	0.635	0.635	0.510/0.254	0.381/0.102
14-11	0.762	0.762	1.14	1.14	1.14	0.762	0.762	0.510/0.254	0.381/0.102
10-9	0.762	0.762	1.14	1.14	1.14	0.762	0.762	0.510/0.254	0.510/0.102
1000 V (Control Cables Only)									
16	1.14	1.14	1.14	1.14	1.14	1.14	1.14	0.762/0.381	---
14-9	1.14	1.14	1.92	1.52	1.52	1.14	1.14	0.762/0.381	---

3.4 REQUIREMENTS

When tested in accordance with appropriate methods specified in Part 6, the insulation shall meet the applicable requirements specified in Table 3-2.

3.4.1 Crosslinked Polyethylene (XLPE) Insulation, Type I and Type II

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 90°C.

3.4.2 Ethylene Propylene Rubber (EP) Insulation, Type I and Type II

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 90°C.

3.4.3 Ozone Resisting Silicone Rubber (SR) Insulation

This insulation shall be suitable for use in dry locations at a temperature not exceeding 125°C.

3.4.4 Chlorosulfonated Polyethylene (CSPE) Insulation

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 90°C.

3.4.5 Polyvinyl-Chloride (PVC) Insulation

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 75°C. When tested in accordance with 6.22, the insulation shall have a dielectric strength retention of not less than 60% of the original value. Conductors having a nylon covering (see 3.2.3) shall not show any cracks when subjected to the wrap test given in Part 6 (6.9.8). Wrinkles in the covering shall not constitute failure of this requirement.

3.4.6 Polyvinyl Chloride/Nylon (PVC/Nylon) Insulation

This insulation shall be suitable for use at conductor temperatures not exceeding 90°C in dry locations or 75°C in wet locations.

When tested in accordance with 6.22 the insulation shall have a dielectric strength retention of not less than 60% of the original value.

The nylon covering shall not show any cracks when subjected to the wrap test given in Part 6 (6.9.8). Wrinkles in the covering shall not constitute failure of this requirement.

3.4.7 Polyethylene (PE) Insulation

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 75°C. The polyethylene material, prior to application to the conductor, shall comply with the requirements of ASTM D 1248 for Type I, Classes A, B, or C, Category 4 or 5, Grade E4 or E5. These requirements do not apply to insulation removed from the conductor. Conductors having a nylon covering shall not show any cracks when subjected to the wrap test given in Part 6. Wrinkles in the covering shall not constitute failure of this requirement.

3.4.8 Composite Insulation

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 90°C. The composite insulation shall consist of an inner layer of Type I or Type II EP with an outer layer of insulating chlorosulfonated polyethylene (CSPE) or neoprene (CR). When the inner and outer insulating layers can be separated without injury to either layer, they shall be tested separately for compliance with the physical and aging requirements given in Table 3-2. When the layers cannot be separated, they shall be tested as a unit for compliance with the physical and aging requirements given in Table 3-2. The composite insulation, whether strippable or non-strippable, shall be tested as a unit to determine compliance with the electrical and moisture absorption requirements given in Table 3-2.

3.4.9 Styrene Butadiene Rubber (SBR) Insulation

This insulation is suitable for use at conductor temperatures not exceeding 75°C in dry locations and 60°C in wet locations.

3.4.10 Thermoplastic Elastomer (TPE) Insulation, Type I and Type II

This insulation shall be suitable for use in wet or dry locations at a temperature not exceeding 75°C or in dry locations only at a temperature not exceeding 90°C.

3.4.11 Jacket over Insulation

Jackets shall not be required over the individual conductors. However, if a jacket is used, it shall meet the minimum requirements of minimum average thickness of not less than 0.015 in.. The minimum thickness at any one point shall not be less than 80% of this value.

3.4.12 Repairs

When repairs in the insulation are required, they shall be made such that the repaired part meets the dielectric withstand requirements specified in 3.4 and the insulation resistance requirements specified in 3.5. The thickness of the repaired part shall conform to the thickness requirements given in 3.2.

3.5 VOLTAGE TESTS

3.5.1 Production Tests

Each production or shipping length of completed cable shall be tested in accordance with ICEA T-27-581/NEMA WC 53 except that the test may be made without immersion in water. The insulated conductors shall withstand for 5 min either the AC test voltage given in Table 3-3, or a DC test voltage of three times the AC test voltage. The test voltage of the cable shall be based on the rated voltage of the cable and the conductor size and not on apparent thickness of the insulation.

3.5.2 Acceptance Testing after Installation

See Appendix G.

Table 3-2
INSULATION REQUIREMENTS

Properties	Composite Insulation (d)																
									Separable Layers				Non-separable				
	XLPE		EP Rubber								TPE		EP		Composite		
	Type I	Type II	Type I	Type II	SR Rubber	CSPE Rubber	PVC	PE	PVC/Nylon	Type I	Type II	Type I	Type II	CSPE or CR	EP/CSPE or EP/CR	SBR	
Initial Tensile Strength, minimum psi	1800	1800	700	1200	800	1500	2000	1400	2000 (g)	1500	1500	700	1200	1500	1000	700	
Initial Elongation at Rupture, minimum %	250	150	250	150	250	300	150	350	150(g)	300	300	250	150	300	250	300	
Tensile Stress,																	
At___ % Elongation,	---	---	---	100	---	---	---	---	---	---	---	---	100	---	---	---	
Minimum, psi	---	---	---	500	---	---	---	---	---	---	---	---	500	---	---	---	
Retention, minimum %																	
of Tensile Strength	75	85	75	75	500(a)	85	80	75	75	75	75	75	75	85	75	80	
of Elongation	75	60	75	75	125(a)	50	75	75	65	75	75	75	75	40	50	60	
After Air Oven																	
Exposure at °C±1°C	121	121	121	121	200	121	121	100	136(g)	121	121	121	121	121	121	100	
For___Hrs	168	168	168	168	168	168	168	48	168	168	168	168	168	168	168	168	
Retention, Minimum %																	
of Tensile Strength	---	---	---	---	---	60	85	---	50(g)	---	---	---	---	---	---	---	
of Elongation	---	---	---	---	---	60	85	---	50(g)	---	---	---	---	---	---	---	
After Oil Immersion																	
°C±1°C	---	---	---	---	---	121	70	---	100(h)	---	---	---	---	---	---	---	
For___Hrs	---	---	---	---	---	18	4	--	96	---	---	---	---	---	---	---	

Properties	Composite Insulation (d)																
									Separable Layers								Non-separable
									TPE				EP				
	Type I	Type II	Type I	Type II	SR Rubber	CSPE Rubber	PVC	PE	PVC/ Nylon	Type I	Type II	Type I	Type II	CSPE or CR	EP/CSPE or EP/CR	SBR	
Heat distortion, Maximum % at °C±1°C	30	30	---	---	---	---	25	--	25	25	25	---	---	---	---	---	
	121	121	---	---	---	---	121	--	136	121	121	---	---	---	---	---	
Hot Creep @ 150°C±2°C	(e)	(e)	(e)	(e)	---	(e)	---	--	---	---	---	(e)	(e)	(e)	(e)	(e)	
Ozone Resistance After 3 hr Exposure	---	---	---	---	Pass	---	---	--	---	---	---	---	---	---	---	---	
Heat Shock @ 121°C±1°C	---	---	---	---	---	---	No Cracks	--	---	---	---	---	---	---	---	---	
Type A Flame Test	---	Pass	---	---	---	---	---	--	---	---	---	---	---	---	---	---	
Type B Flame Test	---	---	---	---	---	Pass	Pass	--	Pass	---	Pass	---	---	---	---	---	
Cold Bend After 1 Hr At °C±2°C	---	---	---	---	---	-25	-30	--	-25	---	---	---	---	---	---	---	
Minimum Requirements	---	---	---	---	---	No Cracks	No Cracks	--	No Cracks	---	---	---	---	---	---	---	
Environmental Stress Cracking	---	---	---	---	---	---	---	No Cracks	--	---	---	---	---	---	---	---	
Electrical Properties after Immersion in 75°C±1°C Water, Permittivity (SIC)after 24 Hr, Maximum Increase in Capacitance, maximum %	6.0	6.0	4.0	6.0	---	10.0	10.0	--	10.0(g)	3.0	4.0	4.0	6.0	---	4.5	6.0	
1-14 Days	3.0	4.0	3.5	5.0	10.0	6.0	4.0	---	6.0(g)	3.0	4.0	3.5	5.0	---	3.5	10.0	
7-14 Days	1.5	2.0	1.5	3.0	3.0	2.0	2.0	--	3.0(g)	1.5	2.0	1.5	3.0	---	2.0	4.0	
Stability Factor After 14 Days, maximum*	1.0	1.0	1.0	1.0	---	1.0	---	---	--	1.0	1.0	1.0	1.0	---	1.0	1.0	
Alternate to Stability Factor, maximum* Difference, 1-14 Days	0.5	.05	0.5	---	---	0.5	---	---	--	0.5	0.5	0.5	---	---	---	0.5	

Properties	Composite Insulation (d)																SBR
											Separable Layers				Non-separable		
	XLPE		EP Rubber								TPE		EP		Composite		
	Type I	Type II	Type I	Type II	SR Rubber	CSPE Rubber	PVC	PE	PVC/ Nylon	Type I	Type II	Type I	Type II	CSPE or CR	EP/CSPE or EP/CR		
Insulation Resistance Constant k @ 15.6°C, Minimum gigaohms-1000 ft(c)	10	10	20	10	4	1	2	50(b)	3	40	40	20	10	---	12	4	
Mechanical Water Absorption, Maximum Milligrams per Sq In. after 168 hr 70°C±1°C	---	---	---	---	---	---	---	---	--	---	---	---	---	35	35	20	
Specific Surface Resistance, minimum gigaohms(c)	---	---	---	---	---	---	---	---	--	---	---	---	---	200	200	---	

NOTES—

- Values are minimum tensile strength (psi) and elongation (%) after exposure, not retained percentages.
- Value shall be not less than 30, based on the sum of the thickness of the two layers, if a layer of PVC is applied over the PE.
- It may be more convenient at times to express this value in megohms (1 gigaohm = 10³ megohms).
- See 3.3.8.
- For Engineering Information only.
- A dash under any insulation indicates that a particular value for the applicable property is not required.
- With Nylon removed.
- Conditioned with nylon intact.

* Only one of these requirements needs to be satisfied, not both