NEMA WC*53 90 ■ 6470247 0500282 6 ■

NEMA STANDARDS PUBLICATION/NO. WC 53-1990
ICEA PUBLICATION NO. T-27-581

icea/nema

Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test





NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., SUITE 300, WASHINGTON, D.C. 20037
INSULATED CABLE ENGINEERS ASSOCIATION ■ P.O. BOX 440, SOUTH YARMOUTH, MA 02664

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA WC*53 90 ■ 6470247 0500283 8 ■

ICEA T-27-581/NEMA WC 53-1990

WC 53

STANDARD TEST METHODS FOR EXTRUDED DIELECTRIC POWER, CONTROL, INSTRUMENTATION, AND PORTABLE CABLES

Developed by:

Insulated Cable Engineers Association, Inc.
P.O. Box 440
South Yarmouth, MA 02664

Approved as a NEMA Standards Publication and Published by:

National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
Washington, DC 20037

© 1990 by National Electrical Manufacturers Association

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

TABLE OF CONTENTS—CONDENSED

		Page
	FOREWORD	i
	SCOPE	ii
Section 1	Industry Standards Referenced in this Document	1
Section 2	Electrical Methods	3
Section 3	Dimensional Methods	9
Section 4	Physical Demands	11

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

TABLE OF CONTENTS

		Page
	FOREWORD	i
	SCOPE	ii
Section 1	INDUSTRY STANDARDS REFERENCED IN THIS DOCUMENT	1
Section 2	ELECTRICAL METHODS	
	Conductor DC Resistance	3
	Method When Sample Nominal Resistance is 1 Ohm or More	3
	Method When Sample Nominal Resistance is Less than 1 Ohm	3
	Precautions for Short Sample Method	3
	Converting Measured Conductor Resistance to Resistance at 25°C	3
	Voltage Withstand	4
	AC Voltage	4
	DC Voltage	4
	Insulation Resistance	4
	Single Conductor Cables	4
	Multiple Conductor Cables	4
	Converting Measured Insulation Resistance to Resistance at 15.6°C (60°F)	4
	Converting Insulation Resistance to Insulation Resistance Constant	5
	Dissipation Factor (DF), Capacitance (C), and Permittivity (SIC)	5
	Spark Testing	5
	Equipment	5
	Procedure	5
	Suitability of Insulation Compounds for Use on DC Circuits in Wet Locations	7
	Accelerated Water Absorption Test, Electrical Method at 60 Hz (EM-60)	7
	Permittivity and Voltage Withstand for Nonconducting Stress Control Layers	7
	Specific Surface Resistivity	8
	U-Bend Discharge Resistance	8
	Track Resistance	8
Section 3	DIMENSIONAL METHODS	
	Conductor Cross-Sectional Area by Diameter Measurements	9
	Thickness of Components over a Conductor	9
	Optical Measuring Device Method for Any Component	9
	Micrometer, Method for Unbonded Components	9
	Diameter over Cable Components	9
	Micrometer Method for Conductors	9
	Micrometer Method for Any Component Except Conductors	10
	Tape Method for Any Component Having a Diameter 0.750 Inch or Greater	10
Section 4	PHYSICAL DEMANDS	
	Adhesion (Stripping Force)	11
	Cold Bend	11
	Heat Deformation (Distortion)	11
	Insulation Deformation	11
	Deformation of Jackets, Insulating and Conducting	12
	Flexibility	12
	Tear Resistance	12
	Gravimeteric Water Absorption	12
	Direction and Length of Lay	13

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Jacket Irregularity Inspection 13
Hot Creep Test 13
Vertical Tray Flame Test 13

LIST OF TABLES

		Page
Table 2-1	Factors for Converting Measured DC Resistance of Conductors to 25°C	4
Table 2-2	Factors for Converting Insulation Resistance to 15.6°C (60°F)	6
Table 4-1	Load vs. Conductor Size in Heat Deformation Test	12
Table 4-2	Jacket Irregularity Inspection	13

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Foreword

This *Standard Test Methods Publication for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables* was developed by the Insulated Cable Engineers Association, Inc. and was approved by the National Electrical Manufacturers Association.

ICEA/NEMA Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturers and the user and to assist the user in selecting and obtaining the proper product for his or her particular need. The user of this Standards Publication is cautioned to observe any health or safety regulations and rules relative to the use of the test procedures covered by this document.

Requests for interpretation of this standard must be submitted in writing to the Insulated Cable Engineers Association, Inc., P.O. Box 440, South Yarmouth, MA 02664. An official written interpretation will be provided by the Association.

Suggestions for improvement gained in the use of this publication will be welcomed by the Association.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Scope

This standard applies to the testing of extruded dielectric insulated power, control, instrumentation, and portable cables.

Included in this standard are many, but not all, of the test methods to which reference is made in ICEA/NEMA Standards for Cables.

Additional test methods that may be germane to several cable designs are described in various ASTM documents and in the following ICEA Publications:

T–24–380	*Partial Discharge*
T–25–425	*Volume Resistivity of Conducting Polymeric Components*
T–28–562	*Proposed Guide for Hot Creep of Polymeric Insulations*

Not all the tests mentioned above are relevant for a given cable design or a given application.

A few specialized test methods are described in ICEA/NEMA Standard Publications, for example, S–19–81/WC 3, *Rubber Insulated Wires and Cables.*

When a procedure for measuring a specified parameter is not specified, that parameter shall be determined by any suitable means.

When another standard is referenced in this document, its title and date of issue may be found in Section 1. The reference is only to that specified document.

In this standard, temperatures are expressed in degrees Celsius, weights in grams, and metal resistivities in nanoohm·meter. Other properties are expressed in non-metric units used in the U.S.A.

Room temperature is defined as 23±5°C. Where this temperature range cannot be maintained, (test) measurements may be made at the prevailing ambient room temperature, which shall be recorded.

The Fahrenheit equivalents for Celsius degrees may be calculated by the equation °F = (1.8 × °C) + 32. The ounce equivalents to grams may be calculated by dividing the number of grams by 28.4. The ohm cmil per foot equivalents to nanoohm·meter may be calculated by multiplying the nanoohm·meter value by 0.602.

Conductor size is expressed in cross-sectional area in thousand circular mils (kcmil). For convenience, in the text and tables, only the equivalent AWG size is used for 211.6 kcmil (4/0 AWG) and smaller. For kcmil values of AWG sizes see the following table:

AWG	kcmil	AWG	kcmil	AWG	kcmil
22	0.640	13	5.18	4	41.74
21	0.812	12	6.53	3	52.62
20	1.02	11	8.23	2	66.36
19	1.29	10	10.38	1	83.69
18	1.62	9	13.09	1/0	105.6
17	2.05	8	16.51	2/0	133.1
16	2 58	7	20.82	3/0	167.8
15	3.26	6	26.24	4/0	211.6
14	4.11	5	33.09		

To convert values in a non-metric unit to the approximate value in an appropriate metric unit, multiply the value in the non-metric unit by the appropriate number from the following table:

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

From	To	Multiplier
inches (in)	milimeters (mm)	25.4
feet (ft)	meter (m)	0.305
ohms per 1000 feet (Ω/1000 ft)	milliohms per meter (mΩ/m)	3.28
square inch (in^2)	square millimeter (mm^2)	645
thousand circular mils (kcmil)	square millimeter (mm^2)	0.507
kilovolts per inch or volts per mil (kV/in or V/mil	megavolts per meter or kilovolts per millimeter (MV/m or kV/mm)	0.0394
pounds per square inch (psi)	kilopascals (kPa)	6.89
pounds tension or force per inch (lb/in)	newtons per meter (N/m)	175
megohms-1000 ft (MΩ-1000 ft)	megohms-meter (MΩ-m)	305
gigaohms-1000 ft (GΩ-1000 ft)	gigaohms-meter (GΩ-m)	305
liquid ounces (liq oz)	cubic centimeter (cm^3)	29.6

In this standard the following nomenclature is used:

Jacket—a polymeric (nonmetallic) protective covering
Insulation Shield—a conducting polymeric (nonmetallic) layer
Cable Shield—a metallic layer
Sheath—a metallic layer
Armor—a metallic layer

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

NEMA WC*53 90 ■ 6470247 0500290 5 ■

Section 1
INDUSTRY STANDARDS REFERENCED IN THIS DOCUMENT

Copies of the above documents may be obtained from the appropriate source as follows:

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, PA 19103

ASTM B 193–78	*Resistivity of Electrical Conductor Materials, Test for*
ASTM D 257–78	*DC Resistance of Conductance of Insulating Materials, Test for*

Insulated Cable Engineers Association, Inc.
P.O. Box 440
South Yarmouth, MA 02664

ICEA T–28–562	*Measurement of Hot Creep of Polymeric Insulations, Test Methods for*
ICEA T–29–520	*Procedure for Conducting Vertical Tray Flame Tests with a Theoretical Heat Input Rate of 210,000 B.T.U./Hour*
ICEA T–30–520	*Procedure for Conducting Vertical Cable Tray Flame Tests with a Theoretical Heat Input Rate of 70,000 B.T.U./Hour*

National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161

National Bureau of Standards Handbook No. 100	*Copper Wire Tables (February 4, 1966)*
National Bureau of Standards Handbook No. 109	*Aluminum Wire Tables (February 1972)*

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

STANDARD TEST METHODS FOR EXTRUDED DIELECTRIC POWER, CONTROL, INSTRUMENTATION, AND PORTABLE CABLES

Section 2
ELECTRICAL METHODS

2.1 CONDUCTOR DC RESISTANCE

DC resistance shall be determined on a sample of any length of a foot or longer. When the nominal resistance of the sample is 1 ohm or more, the procedure in 2.1.1 shall be followed. When the nominal resistance of the sample is less than 1 ohm, the procedure in 2.1.2 shall be followed. When a sample is cut from a longer length, either for the original measurement or to verify the measurement on the long length, the procedure in 2.1.2 and precautions in 2.1.3 shall be followed.

2.1.1 Method When Sample Nominal Resistance is 1 Ohm or More

The dc resistance shall be measured with a Kelvin bridge, a potentiometer, or a Wheatstone bridge.

2.1.2 Method When Sample Nominal Resistance is Less Than 1 Ohm

The dc resistance shall be measured with a Kelvin bridge or a potentiometer.

2.1.3 Precautions for Short Sample Method

When measurements are made on a short sample, the following precautions shall be taken:

2.1.3.1 Current contacts shall be made in such a way as to ensure essentially uniform current density among the wires.

2.1.3.2 When potential leads are used, the distance between each potential contact and the corresponding current contact shall be at least equal to 1.50 times the circumference of the specimen. When a Kelvin-type bridge is used, the yoke resistance (between reference standard and test specimen) shall be appreciably smaller than that of either the reference standard or the test specimen unless a suitable lead compensation is used or it is known that the coil and lead ratios are sufficiently balanced so that variation in yoke resistance will not decrease the bridge accuracy below that given in 2.1.3.4.

2.1.3.3 The distance between potential electrodes shall be measured to an accuracy of ±0.05 percent. To ensure this accuracy in measuring the length between potential contacts, the surface in contact with the test specimen shall be a substantially sharp knife edge.

2.1.3.4 Resistance measurements shall be made to an accuracy of ±0.15 percent. To ensure a correct reading, the reference standard and the test specimen should be allowed to come to the same temperature as the surrounding medium. (If the reference standard is made of manganin, it is possible to obtain correct readings with the test specimen at reference temperatures other than room temperature.)

2.1.3.5 In all resistance measurements, the measuring current raises the temperature of the medium. Therefore, the magnitude of the current shall be low and the time of its use short enough so that changes in resistance cannot be detected with the galvanometer.

2.1.3.6 In bridge measurements, the potential contact resistance shall be as low as possible. If low contact resistance cannot be achieved, appropriate contact-resistance corrective circuits shall be used. To eliminate errors due to contact potential, two readings, one direct and one with current reversed, shall be taken in direct succession. Check tests may be made by turning the specimen end for end and repeating the test. The material used for the two potential contacts shall be the same to minimize imbalanced contact potentials. If necessary, the contact surfaces shall be cleaned.

2.1.4 Converting Measured Conductor Resistance to Resistance at 25°C

To convert measured resistance to resistance at 25°C, the formulas and tabulated factors given in Table 2-1 or the procedure in ASTM B 193 shall be used.

The conversion factors given in Table 2-1 are satisfactory for most applications. They are based upon copper having 100 percent conductivity (resistivity = 17.582 nanoohm·meter at 25°C) and aluminum having 61 percent conductivity (resistivity = 28.834 nanoohm·· meter at 25°C). The factors are derived from the formulas:

$$R_1 = R_2\left(\frac{259.5}{234.5+T_2}\right) \text{ for copper}$$

$$R_1 = R_2\left(\frac{253.0}{228.0+T_2}\right) \text{ for aluminum}$$

Where:

R_1 = Resistance at 25°C

R_2 = Measured Resistance at Temperature T_2

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

For more accurate determination of resistance, allowing for different conductivities, see *Copper Wire Tables*, National Bureau of Standards, Handbook No. 100 or *Aluminum Wire Tables*, National Bureau of Standards Handbook 109 and ASTM B 193.

Table 2-1
FACTORS FOR CONVERTING MEASURED DC RESISTANCE OF CONDUCTORS TO 25°C

Temperature, °C	Multiplying Factor for Copper	Multiplying Factor for Aluminum
0	1.107	1.110
5	1.084	1.085
10	1.061	1.063
15	1.040	1.041
20	1.020	1.020
25	1.000	1.000
30	0.981	0.981
35	0.963	0.962
40	0.945	0.944
45	0.928	0.927
50	0.912	0.910
55	0.896	0.894
60	0.881	0.878
65	0.866	0.863
70	0.852	0.849
75	0.838	0.835
80	0.825	0.821
85	0.812	0.808
90	0.800	0.796

2.2 VOLTAGE WITHSTAND

The voltage that an insulated conductor is required to withstand shall be applied, in accordance with 2.2.1 or 2.2.2, between the insulated conductor and the specified ground.

2.2.1 AC Voltage

An ac voltage having a frequency of 55±6 Hz, not greater than the rated ac voltage of the cable, shall be applied. The voltage then shall be raised at a uniform rate to the specified value. The rate shall be not more than 100 percent in 10 seconds or less than 100 percent in 60 seconds. The specified voltage shall be held for the specified time.

2.2.2 DC Voltage

A dc voltage, not greater than 3.0 times the rated ac voltage of the cable, shall be applied. The voltage then shall be raised at a uniform rate to the specified value. The rate shall be not more than 100 percent in 10 seconds or less than 100 percent in 60 seconds. The specified voltage shall be held for the specified time.

2.3 INSULATION RESISTANCE

The test apparatus shall be in accordance with ASTM D 257. Measurements shall be taken according to 2.3.1 or 2.3.2. The conductor under the test shall be connected to the negative terminal of the test equipment and readings shall be taken after an electrification of 60 seconds with a dc voltage of 300±200 volts.

2.3.1 Single Conductor Cables

Measurements shall be taken between the conductor and cable shield or water...

2.3.2 Multiple Conductor Cables

2.3.2.1 NONSHIELDED CABLES

Measurements shall be taken between each conductor and all other conductors connected to ground.

2.3.2.2 SHIELDED CABLES

Measurements shall be taken between the conductor and cable shield.

2.3.3 Converting Measured Insulation Resistance to Resistance at 15.6°C (60°F)

Three representative samples shall be obtained. Preferred are 14 AWG wires with a 0.045-inch wall of insulation. The samples shall be of sufficient length to yield insulation resistance values that are within the calibrated range of the measuring instrument at the lowest water bath temperature.

The three samples shall be immersed in a water bath equipped with heating, cooling, and circulating facilities, with the ends of the samples extended at least 2 feet above the surface of the water and properly prepared for minimum leakage. The samples shall be left in the water at room temperature for 16 hours before adjusting the bath temperature to 10°C or before transferring the samples to 10°C test temperature bath.

The resistance of the conductor shall be measured at suitable intervals until it remains unchanged for at least 5 minutes. The insulation will then be at the temperature of the bath as read on the bath thermometer. Insulation resistance shall then be measured in accordance with 4.1.

Each of the three samples shall be exposed to successive water temperature of 10, 16, 22, 28, and 35°C and, returning, 28, 22, 16, and 10°C. Insulation resistance reading shall be taken at each temperature after equilibrium has been established.

The two sets of readings taken at the same temperature shall be averaged and, together with the reading at 35°C, plotted on semi-log paper with temperature along the

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

linear axis. The insulation resistance value at 15.6°C (60°F) shall be read from the plot.

The 1°F coefficient shall be calculated by dividing the insulation resistance at 15.6°C (60°F) by that at 16.1°C (61°F).

The resistivity coefficient, C, rounded off to two decimal places, shall be used to enter the appropriate column in Table 2-2 in order to find the factor for converting to insulation resistance at 15.6°C (60°F), the insulation resistance measured at the temperature, t, of the production or shipping length.

2.3.4 Converting Insulation Resistance to Insulation Resistance Constant

Themeasured insulation resistance (IR), converted to resistance at 15.6°C (60°F), shall be converted to insulation resistance constant (IRK) by use of measured diameters and the following equation:

$$IR = (IRK) \cdot \log_{10}\left(\frac{D}{d}\right)$$

Where:

IR =Insulation resistance in megohms-1000 ft, at 15.6°C

IRK =Insulation resistance constant in megohms-1000 ft

D =Diameter over the insulation in inches

d =Diameter over conductor stress control layer, when present, or over conductor, in inches

Note—It may be more convenient, at times, to express IR and IRK in gigaohms- or teraohms-1000 ft. A gigaohm equals 10^9 ohms, a teraohm equals 10^{12} ohms, while a megohm equals 10^6 ohms.

2.4 DISSIPATION FACTOR (DF), CAPACITANCE (C), AND PERMITTIVITY (SIC)

The minimum length of a cable sample for measuring DF and C shall be 15 feet.

C and DF shall be determined at the specified frequency and temperature, using a suitable ac bridge, e.g., a Schering or a Transformer-Ratio-Arm bridge. The measurements shall be made at U_0 (the voltage between conductor and ground of a three-phase system). U_0 is the rated voltage divided by the square root of three. The measured capacitance shall be length adjusted to picofarads per foot, using the measured length of cable between electrodes.

The equivalent geometric capacitance (C_0), shall be calculated from the formula:

$$C_0 = 7.354/\log_{10}\left(\frac{D}{d}\right)$$

Where:

C_0 = Equivalent geometric capacitance, in picofarads per foot

D =Diameter over insulation, in inches

d =Diameter over conductor stress control layer, when present, or over conductor, in inches

The ratio of the measured capacitance divided by the geometric capacitance (C/C_0) shall be the permittivity (Specific Inductive Capacity or SIC) of the sample.

2.5 SPARK TESTING

Use of spark test equipment to evaluate irregularities of jackets over metal components is covered in 4.8.

2.5.1 Equipment

A spark tester shall include a suitable source of ac or dc potential, an electrode, a voltmeter, a fault-signal device or system, and the necessary electrical connections.

Under all normal conditions of leakage current, the potential source of a spark tester shall maintain the specified test voltage between the electrode and ground. The core of a transformer as well as one end of its secondary winding shall be reliably connected to ground (earth). A potential source shall not be connected to more than one electrode.

The electrode shall be of the link- or bead-chain or other type capable of maintaining contact throughout its length with the periphery of the cable being tested.

The bottom of the metal electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be approximately 1.5 inches greater than the diameter of the largest size of wire that is tested.

If a bead-chain electrode is used, the beads shall have a diameter of 3/16 inch. The longitudinal spacing of the chains shall not be more than ½ inch. The transverse spacing of the chains shall not be more than 3/8 inch but a spacing of ½ inch is acceptable if the transverse rows of chain are staggered.

The electrode shall be provided with an grounded (earthed) metal screen or an equivalent guard to prevent persons from touching the electrode.

The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

The equipment shall include a light, counter, or other device or system that gives a visible signal in the event of a fault. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

2.5.2 Procedure

The length of the electrode is not specified, but the rate of speed at which the wire travels through the electrode shall ensure that any point on the wire is in contact with the electrode for not less than 0.05 seconds with dc or 9 cycles with ac, i.e. 0.15 seconds for 60 Hz and 0.18 seconds for 50 Hz.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table 2-2
FACTORS* FOR CONVERTING INSULATION RESISTANCE TO 15.6°C (60°F)

Temperature		Resistivity Coefficient for 0.55°C (1°F)									
°F	°C	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
40	4.4	0.55	0.46	0.38	0.31	0.26	0.22	0.18	0.15	0.12	0.10
41	5.0	0.57	0.48	0.40	0.33	0.28	0.23	0.19	0.16	0.14	0.12
42	5.6	0.59	0.49	0.42	0.35	0.30	0.25	0.21	0.18	0.15	0.13
43	6.1	0.60	0.51	0.44	0.37	0.32	0.27	0.23	0.20	0.17	0.15
44	6.7	0.62	0.53	0.46	0.39	0.34	0.29	0.25	0.22	0.19	0.16
45	7.2	0.64	0.56	0.48	0.42	0.36	0.32	0.28	0.24	0.21	0.18
46	7.8	0.66	0.58	0.50	0.44	0.39	0.34	0.30	0.26	0.23	0.20
47	8.3	0.68	0.60	0.53	0.47	0.42	0.37	0.33	0.29	0.26	0.23
48	8.9	0.70	0.62	0.56	0.50	0.44	0.40	0.36	0.32	0.29	0.26
49	9.4	0.72	0.65	0.59	0.53	0.48	0.42	0.39	0.35	0.32	0.29
50	10.0	0.74	0.68	0.61	0.56	0.51	0.46	0.42	0.39	0.35	0.32
51	10.6	0.77	0.70	0.64	0.59	0.54	0.50	0.46	0.42	0.39	0.36
52	11.1	0.79	0.73	0.68	0.63	0.58	0.54	0.50	0.47	0.43	0.40
53	11.7	0.81	0.76	0.71	0.67	0.62	0.58	0.55	0.51	0.48	0.45
54	12.2	0.84	0.79	0.75	0.70	0.67	0.63	0.60	0.56	0.54	0.51
55	12.8	0.86	0.82	0.78	0.75	0.71	0.68	0.65	0.62	0.59	0.57
56	13.3	0.89	0.86	0.82	0.79	0.76	0.74	0.71	0.68	0.66	0.64
57	13.9	0.92	0.89	0.86	0.84	0.82	0.79	0.77	0.75	0.73	0.71
58	14.4	0.94	0.93	0.91	0.89	0.87	0.86	0.84	0.83	0.81	0.80
59	15.0	0.97	0.95	0.94	0.95	0.94	0.93	0.92	0.91	0.90	0.89
60	15.6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
61	16.1	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
62	16.7	1.06	1.08	1.10	1.12	1.14	1.17	1.19	1.21	1.23	1.25
63	17.2	1.09	1.12	1.16	1.19	1.23	1.26	1.30	1.33	1.37	1.40
64	17.8	1.13	1.17	1.22	1.26	1.31	1.36	1.41	1.46	1.52	1.57
65	18.3	1.16	1.22	1.28	1.34	1.40	1.47	1.54	1.61	1.69	1.76
66	18.9	1.19	1.27	1.34	1.42	1.50	1.59	1.68	1.77	1.87	1.97
67	19.4	1.23	1.32	1.41	1.50	1.61	1.71	1.83	1.95	2.08	2.21
68	20.0	1.27	1.37	1.48	1.59	1.72	1.85	1.99	2.14	2.30	2.48
69	20.6	1.30	1.42	1.55	1.69	1.84	2.00	2.17	2.36	2.56	2.77
70	21.1	1.34	1.48	1.63	1.79	1.97	2.16	2.37	2.59	2.84	3.11
71	21.7	1.38	1.54	1.71	1.90	2.10	2.33	2.58	2.85	3.15	3.48
72	22.2	1.43	1.60	1.80	2.01	2.25	2.52	2.81	3.14	3.50	3.90
73	22.8	1.47	1.67	1.89	2.13	2.41	2.72	3.07	3.45	3.88	4.36
74	23.3	1.51	1.73	1.98	2.26	2.58	2.94	3.34	3.80	4.31	4.89
75	23.9	1.56	1.80	2.08	2.40	2.76	3.17	3.64	4.18	4.78	5.47
76	24.4	1.60	1.87	2.18	2.54	2.95	3.43	3.97	4.59	5.31	6.13
77	25.0	1.65	1.95	2.29	2.69	3.16	3.70	4.33	5.05	5.90	6.87
78	25.6	1.70	2.03	2.41	2.85	3.38	4.00	4.72	5.56	6.54	7.69
79	26.1	1.75	2.11	2.53	3.30	3.62	4.32	5.14	6.12	7.26	8.61
80	26.7	1.81	2.19	2.65	3.21	3.87	4.66	5.60	6.73	8.06	9.65
81	27.2	1.86	2.28	2.79	3.40	4.14	5.03	6.11	7.40	8.95	10.8
82	27.8	1.92	2.37	2.93	3.60	4.43	5.44	6.66	8.14	9.93	12.1
83	28.3	1.97	2.46	3.07	3.82	4.74	5.87	7.26	8.95	11.0	13.6
84	28.9	2.03	2.56	3.23	4.05	5.07	6.34	7.91	9.85	12.2	15.2
85	29.4	2.09	2.67	3.39	4.29	5.43	6.85	8.62	10.8	13.6	17.0

*Calculated from the following formula: $TCF = C^{(t-60)}$ where C is determined in accordance with 3.3 and t is the cable temperature in degrees Fahrenheit.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

The conductor, cable shield, sheath or armor, as applicable, of the cable shall be grounded (earthed) during the spark test. A ground (earth) connection shall be made at both the pay-off and take-up reels except that, if the conductor, cable shield, sheath or armor was tested for continuity prior to conduct of the spark test and found to be of one integral length, the ground (earth) connection need be made at only one point-at either the take-up or pay-off reel. In any case, a reel at which a ground (earth) connection is made shall be bonded directly to the ground (earth) on the potential source of the spark tester.

2.6 SUITABILITY OF INSULATION COMPOUNDS FOR USE ON DC CIRCUITS IN WET LOCATIONS

Samples:

a. Test specimen shall have a nominal 14 AWG solid conductor with 0.047 inch insulation, or the nominal thickness for the applicable voltage rating, whichever is thinner, (no further coverings) conforming to ICEA dimensional tolerances.

b. Three identical specimens shall be used. The center 10-foot section of each specimen shall be immersed in water with adequate end sections at least 12 inches long. These three specimens shall be immersed in the same or identical glass containers (bath).

Water Bath: The water bath (test tank) shall be made of glass and maintained at the specified temperature ±1°C, and shall contain tap water with a pH of 6.0 to 8.0. The water bath shall be connected to ground to serve as the grounded electrode. Only bare copper electrodes shall be used. A suitable cover shall be placed over the water bath and the water maintained at a constant level flush with the surface of the cover.

Test Potential: A negative dc potential of 600 volts shall be applied to the conductors of the three test specimens immediately after immersion and shall be so maintained for the duration of the test except during the measuring intervals. The positive electrode shall be connected to the water bath and ground.

Test Period: Method EM-60 ac measurements in accordance with 2.7 shall be made on each test specimen after a total immersion period of 1 day, 1 week, 2 weeks, and each 2-week period thereafter for a total period of 16 weeks unless sample failure occurs before this period. Immediately previous to the above measurements, a 60-Hz test potential of 5000 volts for 5 minutes is to be applied to each specimen at each measuring interval. The stability factor for each measuring method shall be in accordance with 2.7.

2.7 ACCELERATED WATER ABSORPTION TEST, ELECTRICAL METHOD AT 60 HZ (EM-60)

This test shall be a type test. It shall be performed on insulations or composite insulations that are not in excess of 45±4 mils thick. The conductor size shall be 4 AWG or smaller. There shall be no nonconducting separator between the conductor and insulation. There shall be no coverings over the insulation(s). The cable sample shall be at least 15 feet long. The middle 10 feet of the cable sample shall be immersed in tap water that is maintained at the temperature specified for the insulation or composite insulation being tested for a period of 14 days, keeping not less than 2.5 feet at each end above water as leakage insulation. The test measurements shall be made at the specified test temperature. The water level shall be kept constant.

Capacitance. The capacitance of the insulation shall be determined at an average stress of 80 kV/in at approximately 60 Hz after 1, 7, and 14 days immersion. The increase in capacitance from 1 to 14 days and from 7 to 14 days shall be expressed as a percentage of the 1- and 7-day values, respectively. The dissipation factor of the insulation at an average stress of 80 and 40 kV/in shall be determined after 1 and 14 days immersion. The dissipation factor shall be expressed to the nearest 0.001.

Stability Factor. The stability factor is 100 times the difference between dissipation factor at 80 and 40 kV/in after the test specimen has been immersed in water at the specified test temperature for the specified time. The alternate to the stability factor is the stability factor at the specified time minus stability factor at one day.

Dielectric Constant Calculation. The dielectric constant (specific inductive capacity) of the insulation at 60 Hz shall be calculated as follows:

$$\text{Dielectric constant} = 13600\ C \log_{10} \frac{D}{d}$$

Where:

C=Capacitance in microfarads of the 10-foot (3.05-meter) section.

D=Diameter over the insulation

d=Diameter under the insulation

2.8 PERMITTIVITY AND VOLTAGE WITHSTAND FOR NONCONDUCTING STRESS CONTROL LAYERS

The sample shall be a 18±1 inch long conductor over which 0.015–0.030 inch of nonconducting stress control material has been extruded. The central 12±1 inch length shall be shielded using a silver-painted electrode or equivalent applied to the stress control layer surface. The permittivity of the layer shall be determined at the required temperatures in accordance with 1.4 except that a low voltage 60-Hz capacitance bridge shall be

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA WC*53 90 ■ 6470247 0500297 8 ■

used. Following the permittivity determination and while the specimen is kept at the specified temperature, a 60-Hz ac potential shall be applied between the conductor and the grounded shield (painted electrode) with a rate of rise not in excess of 100 volts per second until dielectric failure occurs. The dielectric withstand stress shall be calculated as follows:

$$S = 2V/(D - d)$$

Where:

S = Dielectric withstand stress, in kV per inch
V = Actual breakdown level, in kilovolts
D = Diameter over stress control layer, in inches
d = Diameter under stress control layer, in inches

2.9 SPECIFIC SURFACE RESISTIVITY

A sample of the completed cable of suitable length shall be immersed, except for the ends, in water at room temperature for 48 hours. At the end of this period, the sample shall be removed from the water, blotted, and allowed to remain at room temperature for 10 minutes. Two 1-inch wide foil electrodes spaced 6 inches apart shall be wound around the cable surface that was immersed. A 375±125 volt dc potential shall be applied between the two electrodes and the resistance shall be measured in accordance with ASTM D 257. The specific surface resistivity shall the calculated as follows:

$$P = 0.524\, R \cdot D$$

Where:

P = Specific surface resistivity, in megohms
R = Measured resistance in megohms per 6-inch spacing
D =Cable diameter in inches

2.10 U-BEND DISCHARGE RESISTANCE

A sample of the completed cable shall be bent, in the form of a U, 180 degrees around a mandrel having the specified diameter.

The bent sample after removal from the mandrel shall be mounted with the apex of the U above and in contact with a smooth metal plate and with the legs of the U perpendicular to the plate. After not less than 30 minutes nor more than 45 minutes following the bending, a source of 60-Hz ac potential at the specified voltage shall be applied between the conductor and the metal plate continuously for the specified time and temperature.

2.11 TRACK RESISTANCE

Track resistance shall be determined in accordance with Method A or Method B.

Method A. The track resistance shall be determined in accordance with ASTM D 2132 modified as followed:

a. Three test specimens of insulated conductor, each 5 ½ inches long, shall be used.
b. Seven electrodes shall be applied to each test specimen, with a ¾ inch minimum space between each electrode. Each electrode shall consist of at least one turn of a 12 AWG coated copper wire wrapped tightly around the copper.
c. Three test specimens shall be placed horizontally in the test chamber at right angles to the axis of the spray and equidistant from the nozzle. The upper half of each specimen shall be dusted. The dust shall then be removed for approximately a 0.05-inch width immediately adjacent to both sides of the three electrodes that are to be energized.
d. The end electrodes, each alternate electrode and the conductor in each test specimen shall be grounded. A 60-Hz potential shall be applied to the remaining three electrodes of each specimen.
e. The test potential shall be raised to 1500 volts and the fog deposit adjusted to give a current between 4 and 10 milliamperes. Failure occurs when the circuit breaker trips.

Note—For further information see IEEE *Transactions on Power Apparatus and Systems*, Volume 84, 1965, page 815 (paper 31 TP 6), Discharge Resistant Characteristics of Polyethylenes for Wire and Cable by E. K. Duffy, S. Jovanovitch, and 1. J. Marwick.

Authorized Engineering Information 5-17-1983.

Method B. The track resistance shall be determined in accordance with the following:

a. The test specimen shall be a strip 2 inches long and at least 0.060 inches thick and shall be taken from the outside of the insulation. The conductor stress control layer shall be removed.
b. An electrode shall be attached near one end of the specimen and to the surface that was the outside surface of the insulation.
c. The specimen shall be immersed in a 0. 1 percent solution of ammonium chloride at ground potential until the electrode contacts the surface of the solution and then withdrawn 1 inch of its immersed length. This procedure shall be repeated four times per minute of a minimum of 10 cycles and a maximum of 50 cycles or until failure occurs. Failure occurs when an arc is maintained for two successive cycles between the electrode and solution across 1 inch of specimen.
d. A 60-Hz test potential shall be applied to the electrode attached to the specimen. The tracking voltage is the voltage at which no failures occur on five consecutive test specimens.

Note—For further information, see IEEE *Transactions on Electrical Insulation*, December 1967, Vol. EI-2, No. 3, Page 137 (Paper 31 TP66-360), Dip-Track Test by C. F. Wallace and C. A. Bailey.

Authorized Engineering Information 5-17-1983.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 3
DIMENSIONAL METHODS

3.1 CONDUCTOR CROSS-SECTIONAL AREA BY DIAMETER MEASUREMENTS

The cross-sectional area of a conductor shall be calculated as follows:

$$A = 10^{-3} \sum_{i=1}^{n} d_i^2$$

Where:

A = Cross-section in kcmil

d_i = Diameter of the ith wire in 0.001 inch units (mils) determined according to the micrometer method for conductor diameter

n = Total number of wires in conductor

When n = 1, the average of three measurements of diameter shall be used for d.

3.2 THICKNESS OF COMPONENTS OVER A CONDUCTOR

When a thickness measurement is required, it shall be made by one of the following methods:

3.2.1 Optical Measuring Device Method for Any Component

Thethickness of any component may be determined with an optical measuring device graduated with at least 0.001-inch divisions. The specimen shall be cut perpendicular to the axis of the sample so as to expose the full cross-section. The average of the minimum and maximum thickness shall be taken as the average thickness.

3.2.2 Micrometer Method for Unbonded Components

The thickness of an unbonded component may be determined with a micrometer graduated with at least 0.001-inch divisions.

The reported thickness shall be the average of readings as follows:

3.2.2.1 EXTRUDED INSULATION SHIELD OR JACKET

Thickness shall be the average of the minimum and maximum thickness of the material.

3.2.2.2 TAPE

Thickness shall be the average of five readings taken at different points of the tape after removal of the tape from at least 6 inches of the cable. The micrometer shall be designed for the tape type as follows:

3.2.2.2.1 POLYMERIC TAPES

Shall be measured with a presser foot 0.25 inch ±0.01 inch in diameter and exerting a total force of 85±3 grams, the load being applied by means of a weight.

3.2.2.2.2 METALLIC TAPES

Shall be measured with a micrometer having flat surfaces on both the anvil and the end of spindle. The sample shall be taken from at least 6 inches of core or cable.

3.2.2.3 INSULATION

Average thickness shall be one-half of the difference between the mean of the maximum and minimum diameters over the insulation at one section perpendicular to the conductor and the average diameter over the conductor or any stress control layer or separator measured at the same section. Insulation minimum thickness shall be the difference between a measurement made over the conductor or any stress control layer or separator plus the thinnest insulation wall, and the diameter over the conductor or any stress control layer or separator. The first measurement used for minimum thickness shall be made after slicing off the opposite side of the insulation. Thickness of any stress control layer or separator shall not be included in the thickness of insulation.

3.2.2.4 SHEATH

Thickness shall be the average of 10 measurements, five of which were made approximately equally spaced around the circumference of a sample (at least 3 inches long) cut perpendicular to the cable axis at one end of the cable length, the other five being made similarly on a sample from the other end.

3.3 DIAMETER OVER CABLE COMPONENTS

3.3.1 Micrometer Method for Conductors

Diameter measurements shall be made with a micrometer or other suitable instrument graduated with at least 0.0001-inch divisions. Measurements shall be taken around the circumference of the conductor perpendicular to the axis of the conductor and on the extensions of a line through the center of the conductor and through the center of two wires, which are 180 degrees apart, in the outer layer. The average of three measurements taken 120 degrees apart shall be taken as the diameter.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA WC*53 90 ■ 6470247 0500299 1 ■

Exception: For solid conductors, the diameter measurements shall be made at each end of the sample and one near the middle of the sample. The average of the three measurements shall be taken as the diameter.

3.3.2 Micrometer Method for Any Component Except Conductors

Diameter measurements shall be made with a micrometer or other suitable instrument graduated with at least 0.001-inch divisions. Measurements shall be taken around the circumference of the component perpendicular to the axis of the component and on the extensions of a line through the center of the component. The average of three measurements taken 120 degrees apart shall be taken as the diameter.

3.3.3 Tape Method for Any Component Having a Diameter 0.750 Inch or Greater

A diameter tape graduated with at least 0.01-inch divisions shall be wrapped one turn (360°) around the circumference of the component, tightly and perpendicular to the axis of the component. The average diameter of the component shall be read directly from the diameter tape.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 4
PHYSICAL METHODS

4.1 ADHESION (STRIPPING FORCE)

From cable samples approximately 15 inches long, remove all coverings over the insulation shield.

Starting at one end of the sample, two parallel longitudinal cuts ½ inch apart and not less than 12 inches long shall be made through the insulation shield. The specimen shall be rotated 180 degrees, and two identical cuts shall be made starting from the same end. Each ½-inch strip shall be peeled back from the cut end for a distance of 2 inches.

The specimen shall be held securely at each end. The 2-inch end of the peeled strip shall be gripped in such a manner that it can be pulled at an angle of 90 degrees to the cable axis.

Each strip shall be peeled from the cable at approximately ½ inch per second for a distance of not less than 10 inches. The angle of pull shall be maintained as close to 90 degrees as possible throughout the test.

The force necessary to remove the strip shall be monitored continuously, and the minimum value shall be recorded.

4.2 COLD BEND

To determine compliance with a cold bend withstand requirement, a sample of completed cable of the specified length shall be subjected to the specified temperature for 1 hour and then bent 180 degrees around a mandrel of the specified diameter immediately upon its removal from the cooling chamber. The bend shall be made at a uniform rate, and the time required to remove the sample from the cooling chamber and complete the test shall not exceed 1 minute.

4.3 HEAT DEFORMATION (DISTORTION)

4.3.1 Insulation Deformation

4.3.1.1 Test Specimens

a. *Insulated Conductors 4/0 AWG and smaller.* The initial diameter of a 1-inch long specimen of the insulated conductor shall be measured with a micrometer caliper having a flat surface on both the anvil and spindle. The diameter of the uninsulated conductor shall be measured also. The thickness, T_1, shall be calculated as follows:

$$T_1 = \frac{D-C}{2}$$

Where:

T_1 = Thickness prior to the heat distortion test.
D = Initial diameter of the insulated conductor.
C = Diameter of the uninsulated conductor.

b. *Insulated Conductors larger than 4/0 AWG.* A sample of insulateon approximately 8 inches long shall be prepared to have a thickness of 0.05±0.01 inch and smooth surfaces. From this sample, test specimens 1 inch long and $\frac{9}{16}\pm\frac{1}{16}$ inch wide shall be prepared.

The thickness of the specimen, T_1, shall be measured with a Randall & Stickney, or equivalent, gauge having a 8-inch diameter foot with no loading other than the 85 grams of the gauge.

4.3.1.2 Test Procedure

The following steps shall be completed in 3 hours. A Randall & Stickney, or equivalent, gauge with a load as indicated in Table 4-1 on the foot, shall be placed in an oven that is preheated to the specified temperature. At the end of 1 hour, the test specimen shall be placed in the oven, and both the gauge and the test specimen shall remain in the oven for 1 hour. At the end of this 1-hour period, the specimen shall be placed directly under the foot of the gauge and allowed to remain in the oven under load for 1 hour at the specified temperature.

At the end of this period, the dial of the gauge shall be read for one of the following:

a. *The value of F for insulated conductors 4/0 AWG and smaller.* The thickness, T_2, shall then be calculated as follows:

$$T_2 = \frac{F-C}{2}$$

Where:

T_2 = Thickness after the heat distortion test.
F = Final outside diameter as read from the gauge.
C = Diameter of the uninsulated conductor.

b. *The value of T_2 for insulated conductors larger than 4/0 AWG.*

4.3.1.3 Calculation of Deformation

The deformation shall be calculated as follows:

$$\text{Deformation, percent} = 100\,\frac{T_1-T_2}{T_1}$$

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table 4-1
LOAD VS. CONDUCTOR SIZE
IN HEAT DEFORMATION TEST

Conductor Size, AWG	Gross Load on Gauge, grams
22–20	150
19–18	300
16	400
14– 8	500
6– 1	750
1/0–4/0	1000
Smoothed Samples from Conductors Larger than 4/0	2000

4.3.2 Deformation of Jackets, Insulating and Conducting

4.3.2.1 Test Specimen

A sample of the jacket, either insulating or conducting (including materials used as jacket and insulation shield) approximately 8 inches long shall be prepared to have a thickness of 0.05±0.01 inch and smooth surfaces. From this sample, test specimens 1 inch long and 9/16 inch wide shall be prepared. Where the diameter of the cable does not permit the preparation of a specimen 9/16 inch wide, a molded sheet of the same compound may be used.

The thickness of the specimen, T_1, shall be measured at room temperature with a Randall & Stickney, or equivalent, gauge having a 3/8 inch diameter foot with no loading other than the 85 grams of the gauge.

4.3.2.2 Test Procedure

The following steps shall he completed in three hours.

The Randall & Stickney, or equivalent, gauge with a load of 2000 grams on the foot shall be placed in an oven which is preheated to the specified temperature. At the end of 1 hour, the test specimen shall be placed in the oven, and both the gauge and the test specimen shall remain in the oven for 1 hour. At the end of this 1-hour period, the specimen shall be placed directly under the foot of the gauge and allowed to remain in the oven under the load for 1 hour at the specified temperature. At the end of this period, the thickness, T_2, shall be read on the dial of the gauge.

4.3.2.3 CALCULATION OF DEFORMATION

The deformation shall be calculated as follows:

$$\text{Deformation, percent} = 100\,\frac{T_1 - T_2}{T_1}$$

4.4 FLEXIBILITY

A suitable length of armored cable shall be bent 180° around the specified mandrel with sufficient tension so it conforms closely to the periphery of the cylinder. While the sample is in this position the armor shall be examined for openings, splits, and cracks. The sample is then straightened, the armor removed, and the conductor assembly examined for damage.

4.5 TEAR RESISTANCE

Each specimen shall be cut with a sharp knife or die. After irregularities, corrugations, and reinforcing cords or wires have been removed, each test specimen shall be not more than 0.150 inch and not less than 0.040 inch thick. Specimens shall be cut longitudinally with a new razor blade to a point 0.150 inch from the wider end.

The two halves of the split end of the test specimen shall be placed in the jaws of the testing machine and the jaws separated at the rate of 20±2 inches per minute. The tear resistance shall be determined by dividing the load in pounds required to tear the section by the thickness of the test specimen in inches.

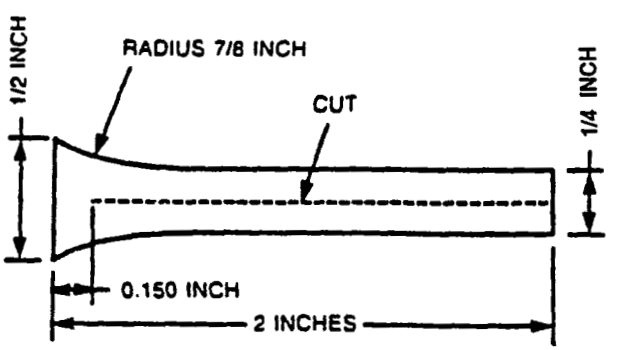

Figure 4-1
TEST SPECIMEN FOR TEAR TEST

4.6 GRAVIMETRIC WATER ABSORPTION

The sample of polymeric material to be tested shall be in the form of a covered wire (weighing less than 100 grams), or a covering removed from a wire and smoothed, or a pressed slab.

The surface of the sample shall be cleaned by scrubbing with a lintless cloth moistened with water, dried for 48 hours in a vacuum of 5 mm of mercury or less over calcium chloride at 70±2°C, and then weighed to the nearest milligram, Weight A.

The surface area, S, shall be the number of square inches immersed in water in a 10-inch length of a covered wire or the total area in square inches immersed in water of other samples.

A covered wire sample shall be bent in the shape of a U around a mandrel having a diameter not less than three

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA WC*53 90 ■ 6470247 0500302 8 ■

times the diameter of the sample. and the ends shall be inserted in tightly fitting holes in the cover of a 16-oz (liquid) jar so that 10 inches of the sample will be immersed when the jar is completely filled with water and the cover applied.

A covering removed from a wire or a pressed slab shall be completely immersed.

The sample shall be immersed for 168 hours in freshly, boiled distilled water that is maintained at the specified temperature ±1°C. The level of the water shall be maintained flush with the undersurface of the cover during the soaking period. After 168 hours, the water shall be cooled to room temperature. The sample shall be removed and the adhering water shaken off. It shall be blotted lightly with lintless cloth and weighed within 3 minutes to the nearest milligram, Weight B.

The sample shall be dried in a vacuum of 5 mm of mercury or less over calcium chloride at 70±2°C for 48 hours and then weighed to the nearest milligram, Weight C.

The water absorption shall be calculated in terms of milligrams per square inch of surface as follows:

$$\text{Water Absorption (if C is less than A)} = \frac{B-C}{S}$$

$$\text{Water Absorption (if C is greater than A)} = \frac{B-A}{S}$$

Where:

A = Weight of the sample in milligrams before immersion.

B = Weight of the sample in milligrams after immersion.

C = Weight of the sample in milligrams after drying in vacuum.

S = Total immersed area in square inches of the sample.

4.7 DIRECTION AND LENGTH OF LAY

Direction of lay—The direction of lay shall be determined visually. When looking along the axis of a conductor, member or cable assembly, a right-hand lay recedes from the observer in clockwise rotation; left-hand recedes in a counterclockwise rotation.

Length of lay—The lay length shall be determined by measuring the axial length of one turn of the helix of a wire, or member of an assembly. The lay length shall be measured using a straight specimen or section with any suitable scale or instrument to an accuracy of 0.1 inch or better.

4.8 JACKET IRREGULARITY INSPECTION

4.8.1 Three methods for jacket irregularity inspection are indicated in Table 4-2. The equipment for Method A is human sight, with the procedure at the discretion of the organization doing the inspection. The equipment and procedure for methods B and C shall be in accordance with 2.5, Spark Testing.

Methods B and C are appropriate only when a metallic component, suitable for the spark test ground (earth) connection, is present under the jacket.

Table 4-2
JACKET IRREGULARITY INSPECTION

Thickness of Jacket		Method A	Method B	Method C
			ac Spark Testing Voltage	
mils	mm		kV	kV
45	1.14	Visual Inspection	2.0	4.0
50	1.27		2.0	4.5
60	1.52		2.5	5.5
65	1.65		2.5	6.0
75	1.90		3.0	6.5
80	2.03		3.0	7.0
85	2.16		3.5	7.5
95	2.41		4.0	8.5
110	2.79		4.5	10.0
140	3.56		5.5	12.5

4.8.2 The function of Methods B and C is to ensure against jacket mechanical defects. Inspection for such defects should be conducted by Method A if:

a. Spark test voltage levels will cause breakdown due to the intrinsic dielectric strength of the jacket material.

b. The insulating quality of an underlying tape will prohibit detection of defects at the applicable spark test voltage level.

c. The jacket is conducting.

Authorized Engineering Information 7-22-1987.

4.9 HOT CREEP TEST

When a method of determining degree of crosslinking of a polymeric electrical cable insulation is required, the procedures as described in ICEA T–28–562 shall be followed.

4.10 VERTICAL TRAY FLAME TEST

When a type test is required on cable determining the relative ability to resist flame propagation in vertical tray, the procedures shall be per 4.10.1 or 4.10.2.

4.10.1 The 70,000 BTU vertical tray flame test shall be performed in accordance with ICEA T–30–520.

4.10.2 The 210,000 BTU vertical tray flame test shall be performed in accordance with ICEA T–29–520.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Standardization Policies and Procedures, p. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 8)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes:

1. NEMA Standard, which relates to a product, process or procedure commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp 7 & 16)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 7 & 16)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon. *(Standardization Policies and Procedures, pp 7 & 16)*

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

July 17, 1990

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

POWER AND CONTROL CABLE SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Alcan Cable
Atlanta, GA 30328

Amercable
Division of Associated Materials
El Dorado, AR 71730

American Electric Cable Company
Holyoke, MA 01040

BICC Cables Corporation
West Nyack, NY 10994

CABLEC Continental Cables Company
York, PA 17405

Carol Cable Company
Pawtucket, RI 02862

Furon Company
Dekoron Division
Aurora, OH 44202

The Kerite Company
Subsidiary of Hubbell, Inc.
Seymour, CT 06483

Laribee Wire Manufacturing Co., Inc.
Jordan, NY 13080

The Okonite Company
Ramsey, NJ 07446

Pirelli Cable Corporation
Florham Park, NJ 07932

The Rockbestos Company
New Haven, CT 06504

Rome Cable Corporation
Rome, NY 13440

Royal Electric, Inc.
Pawtucket, RI 02862

Southwire Company
Carrollton, GA 30119

Triangle PWC, Inc.
New Brunswick, NJ 08903

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale