

ANSI/NEMA WC 53

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



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

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CONTENTS

	Foreword.....	iv
Section 1	General	1
1.1	Scope	1
1.2	References	1
1.2.1	Normative References.....	1
Section 2	Electrical Methods.....	4
2.1	Conductor dc Resistance	4
2.1.1	Method When Sample Nominal Resistance is 1 Ohm or More	4
2.1.2	Method When Sample Nominal Resistance is Less Than 1 Ohm	4
2.1.3	Precautions for Short Sample Method	4
2.1.4	Converting Measured Conductor Resistance to Resistance at 25°C.....	5
2.2	Voltage Tests on Completed Cables	5
2.2.1	General	5
2.2.2	ac Voltage Test.....	6
2.2.3	dc Voltage Test.....	6
2.2.4	Spark Testing	7
2.3	Insulation Resistance	8
2.3.1	Single Conductor Cables.....	8
2.3.2	Multiple Conductor Cables	8
2.3.3	Method to Determine the 1°F Coefficient Factor for an Insulation	8
2.3.4	Converting Insulation Resistance to Insulation Resistance Constant.....	9
2.4	Dissipation Factor (Df), Capacitance (C), and Dielectric Constant	11
2.5	Suitability of Insulation Compounds for Use On Dc Circuits in Wet Locations	11
2.6	Accelerated Water Absorption Test, Electrical Method at 60 hz (Em-60).....	12
2.7	Dielectric Constant and Voltage Withstand for Nonconducting Stress Control Layers.....	12
2.8	Specific Surface Resistivity	13
2.9	U-Bend Discharge Resistance	13
2.10	Track Resistance	13
2.11	Volume Resistivity	14
2.11.1	Conductor Stress Control	14
2.11.2	Insulation Shield	14
2.11.3	Four-electrode Method	15
2.12	Semiconducting Jacket Radial Resistivity Test	15
2.12.1	Sample Preparation	15
2.12.2	Test Equipment Setup	17
2.12.3	Calculation	17
2.13	Dry Electrical Test for Class III Insulations (Shielded Medium Voltage Only).....	18
2.13.1	Test Samples.....	18
2.13.2	Test Procedure	18
2.13.3	Electrical Measurements	18
2.14	Discharge Resistance Test for discharge resistant Insulation	18
2.14.1	Test Specimens.....	18
2.14.2	Test Environment	18
2.14.3	Test Electrodes.....	19
2.15	Wet Insulation Resistance Stability (600–2000 Volts).....	19
Section 3	Dimensional Methods.....	21
3.1	Conductor Cross-Sectional Area by Diameter Measurements	21
3.2	Thickness of Components Over a Conductor	21
3.2.1	Optical Measuring Device Method for Any Component	21
3.2.2	Micrometer Method for Unbonded Components	21
3.2.3	Extruded Insulation or Insulation Shield or Jacket	21
3.2.4	Tape.....	21
3.2.5	Sheath	22

3.2.6	Bedding and Servings	22
3.3	Diameter over Cable Components	22
3.3.1	Micrometer Method for Conductors	22
3.3.2	Method for Any Component Except Conductors	22
3.3.3	Tape Method for Any Component Having a Diameter 0.750 in. (19.1 mm) or Greater	22
3.4	Protrusion and Convolution Measurement	22
Section 4	Physical Methods.....	24
4.1	Adhesion (Stripping Force)	24
4.2	Cold Bend	24
4.3	Heat Deformation (Distortion)	24
4.3.1	Insulation Deformation	24
4.3.2	Deformation of Jackets, Insulating and Conducting	26
4.4	Flexibility Test for Interlocked Armor	26
4.5	Tear Resistance	26
4.6	Gravimetric Water Absorption	27
4.7	Direction and Length of Lay	28
4.8	Jacket Irregularity Inspection	28
4.9	Hot Creep Test	29
4.10	Vertical Tray Flame Test	29
4.10.1	70,000 BTU	29
4.10.2	210,000 BTU	29
4.11	Physical And Aging Tests for Insulation, Jackets, and Nonmetallic Conducting Materials.....	29
4.11.1	Sampling	29
4.11.2	Number of Test Specimens	30
4.11.3	Size and Preparation of Specimens	30
4.11.4	Calculation for Area of Test Specimens	30
4.11.5	Physical Test Procedures	31
4.11.6	Retests	31
4.11.7	Tensile Strength Test	31
4.11.8	Tensile Stress Test	31
4.11.9	Elongation Test	32
4.11.10	Set Test	32
4.11.11	Aging Tests	32
4.11.12	Physical Tests for Nonmetallic Conducting Materials Intended for Extrusion	33
4.12	Absorption Coefficient	33
4.13	Heat Shock	33
4.14	Environmental Cracking	33
4.14.1	Test Specimens	34
4.14.2	Test Procedures	34
4.15	Method For Flexibility Test for Continuous Corrugated Armor	34
4.16	Shrinkback Test	34
4.16.1	Sample Preparation	34
4.16.2	Test Procedure	34
4.17	Wafer Boil Test for Conductor And Insulation Shields	34
4.18	Extruded Insulation Shield Removeability (Field Strippability) Test	35
4.19	Tightness of Polyethylene Jacket to Sheath Test	35

TABLES

Table 1-1	kcmil Equivalent of AWG Conductor Sizes	3
Table 1-2	Conversion Table	3
Table 2-1	Factors for Converting Measured dc Resistance of Conductors to 5°C.....	5
Table 2-2	Temperature Correction Factors (TCF) for Converting Insulation Resistance to 5.6°C.....	10
Table 2-3	Insulation Resistance Stabilization Period.....	19
Table 4-1	Load vs. Conductor Size In Heat Deformation Test.....	25
Table 4-2	Jacket Irregularity Inspection.....	29
Table 4-3	Mandrel Size for Heat Shock Test.....	33

FIGURES

Figure 2-1	Sample Preparation for Radial Resistivity Measurement of Semi-Conducting Jackets.....	16
Figure 2-2	Circuit for Radial Resistivity Measurement of Semi-Conducting Jackets.....	17
Figure 3-1	Procedure to Measure Protrusions and Indentations.....	23
Figure 3-2	Procedure to Measure Convolutions	23
Figure 4-1	Test Specimen for Tear Test.....	27

Foreword

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

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:

Insulated Cable Engineers Association, Inc.
P.O.Box 2694
Alpharetta, Georgia 30023

An official written interpretation will be made by ICEA.

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

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Section 1 General

1.1 Scope

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

1.2 References

Included in this standard are many, but not all, of the test methods to which reference is made in ICEA/NEMA standards for cables. For undated references, the reference shall be to the latest issue. Copies of the following documents may be obtained from the appropriate source as follows:

1.2.1 Normative References

American Society for Testing and Materials (ASTM)

100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

ASTM B 193-02	<i>Test Method for Resistivity of Electrical Conductor Materials</i>
ASTM D257-07	<i>DC Resistance or Conductance of Insulating Materials, Test Method for</i>
ASTM D412-15a	<i>Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension</i>
ASTM D471-12	<i>Standard Test Method for Rubber Property—Effect of Liquids</i>
ASTM D746-07	<i>Standard Test Methods for Brittleness Temperature of Plastics and Elastomers by Impact</i>
ASTM D2132-12	<i>Standard Test Method for Dust-and-Fog Tracking and Erosion Resistance of Electrical Insulating Materials</i>
ASTM D2275-01	<i>Standard Test Method for Voltage Endurance of Solid Electrical Insulating Materials Subjected to Partial Discharge (Corona) on the Surface</i>
ASTM D2765-01	<i>Standard Test Method for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics</i>
ASTM D3349-12	<i>Standard Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black</i>

Global Engineering Documents

15 Inverness Way East
Englewood, CO 80112-5776

ICEA T-28-562	<i>Test Methods for Measurement of Hot Creep of Polymeric Insulations</i>
ICEA T-29-520	<i>Procedure for Conducting Vertical Cable Tray Flame Tests with a Theoretical Heat Input Rate of 210,000 B.T.U./Hour</i>
ICEA T-30-520	<i>Conducting Vertical Cable Tray Flame Tests with a Theoretical Heat Input Rate of 70,000 B.T.U./Hour</i>
ICEA T-24-380	<i>Partial Discharge Test Procedure</i>
ICEA T-25-425	<i>Guide for Establishing Stability of Volume Resistivity of Conducting Polymeric Component of Power Cables</i>

ANSI/NEMA WC 54/ICEA T-26-465

Guide for Frequency of Sampling Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test

ICEA T-28-562 *Test Method for Measurement of Hot Creep of Polymeric Insulations*

ICEA T-31-610 *Test Method for Conducting Longitudinal Water Penetration Resistance Tests on Blocked Conductors*

ICEA T-32-645 *Test Method for Establishing Volume Resistivity Compatibility of Water Blocking Components With Extruded Semiconducting Shield Materials*

ICEA T-34-664 *Test Method for Conducting a Longitudinal Water Penetration Resistance Tests on Longitudinal Water Blocked Cables*

**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)*

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 Standard Publication S-94-649, *Standard for Concentric Neutral Cables Rated 5,000–46,000 Volts*.

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-meters. Other properties are expressed in U.S. customary units throughout this standard. Approximate International System of Units (SI) equivalents are included for information only. Room temperature is defined as $25 \pm 5^{\circ}\text{C}$. 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

$$\text{deg } F = \left[1.8 \left(\text{deg } C \right) \right] + 32$$

The ounce equivalents to grams may be calculated by dividing the number of grams by 28.4.

The ohm cmil per ft. 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 1-1:

Table 1-1
kcmil Equivalent of AWG Conductor Sizes

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 1-2:

Table 1-2
Conversion Table

From	To	Multiplier
inches (in.)	millimeters (mm)	25.4
feet (ft.)	meter (m)	0.305
ohms per 1000 feet ($\Omega/1000$ ft.)	milliohms per meter ($m\Omega/m$)	3.28
square inch (in. ²)	square millimeter (mm ²)	645.0
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)	175.0
megohms/1000 ft. ($M\Omega$ -1000 ft.)	megohms-meter ($M\Omega$ -m)	305.0
gigaohms/1000 ft. ($G\Omega$ -1000 ft.)	gigaohms-meter ($G\Omega$ -m)	305.0
liquid ounces (fl. oz.)	cubic centimeter (cm ³)	29.6

In this standard the following nomenclature is used:

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

Section 2 Electrical Methods

2.1 Conductor dc Resistance

Dc resistance shall be determined on a sample of any length of a minimum of 3 ft. 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. Other measuring techniques may be suitable if the accuracy is determined to meet the requirements of 2.1. 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:

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

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 as follows:

The distance between potential electrodes shall be measured to an accuracy of $\pm 0.05\%$. 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.

Resistance measurements shall be made to an accuracy of $\pm 0.15\%$. 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.)

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.

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 on copper having 100% conductivity (resistivity = 17.582 nanoohm-meter at 25°C) and aluminum having 61% conductivity (resistivity = 28.834 nanoohm-meter at 25°C) The factors are derived from the formulas:

$$R_1 = R_2 \left[\frac{259.5}{234.5 + T_2} \right] \quad \text{for copper} \quad R_1 = R_2 \left[\frac{253.0}{228.0 + T_2} \right] \quad \text{for aluminum}$$

Where:

R_1 = Resistance at 25°C

R_2 = Measured Resistance at Temperature T_2

For more accurate determination of resistance, allowing for different conductivity, 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

Ambient 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 Tests on Completed Cables

2.2.1 General

These tests consist of voltage tests on each length of completed cable. Except for the dc spark test and the ac spark test the voltage shall be applied between the conductor or conductors and the metallic sheath, metallic shield, metallic armor, or water and the rate of increase from the initially applied voltage to the specified test voltage shall be approximately uniform and shall be not more than 100% in 10 seconds nor less than 100% in 60 seconds.

2.2.1.1 Cables Without Metallic Sheath, Shield, or Armor

2.2.1.1.1 Single Conductor Cable and Assemblies without an Overall Jacket

Single conductor cable and assemblies of single conductor cables shall be tested by either the ac voltage test in water (see Section 2.2.2), the dc voltage test in water (see Section 2.2.3), the ac spark test or the dc spark test (see Section 2.2.4).

When wet testing is utilized, the following shall apply:

- a) Single conductor cable and parallel assemblies of single conductor cable shall be immersed in water for at least six hours and tested while immersed, except polyethylene and crosslinked polyethylene insulated cables only require an immersion time of one hour.
- b) Twisted assemblies of two or more conductors without an overall jacket or covering, shall be immersed in water for at least one hour and tested while immersed, except polyethylene and crosslinked polyethylene insulated cables only require an immersion time of 30 minutes.
- c) Each insulated conductor shall be tested against all other conductors connected to the grounded water.

2.2.1.1.2 Multiple-Conductor Cable with an Overall Jacket

Multiple-conductor cables shall be tested prior to application of the jacket by either spark testing or wet testing (see 2.2.1.1.1). After the overall jacket is applied, each insulated conductor shall be tested against all other conductors connected to ground. Immersion in water is not required.

2.2.1.2 Cables With Metallic Sheath, Shield, or Armor

All cables of this type shall be tested with the metallic sheath, shield or armor grounded, without immersion in water, at the test voltage specified. For cables having a metallic sheath, shield or armor over the individual conductor(s), the test voltage shall be applied between insulated conductor(s) and ground. For multi-conductor cables with non-shielded individual conductors having a metallic sheath, shield or armor over the cable assembly, the test voltage shall be applied between each insulated conductor and all other conductors and ground.

2.2.2 ac Voltage Test

This test shall be made with an alternating potential from a transformer and generator of ample capacity but in no case less than 5 kVa. The frequency of the test voltage shall be nominally between 49 and 61 hertz and shall have a wave shape approximating a sine wave as closely as possible.

The initially applied ac test voltage shall be not greater than the rated ac voltage of the cable under test.

The duration of the ac voltage test shall be 5 minutes.

2.2.3 dc Voltage Test

This test shall be made after the insulation resistance test described in 2.3. The equipment for the dc voltage test shall consist of a battery, generator, or suitable rectifying equipment and shall be of ample capacity.

The initially applied dc voltage shall be not greater than 3.0 times the rated ac voltage of the cable.

The duration of the dc voltage test shall be 15 minutes for cables with insulation shield and 5 minutes for cables without insulation shield.