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# PROPOSED, NEW AND REVISED STANDARDS

7VR Page 131
October 18, 1988

TO ALL REPRESENTATIVES OF MEMBER COMPANIES IN THE
POWER AND CONTROL CABLE SECTION

Subject: Revision No. **1** to NEMA Standards Publication for *Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation and Portable Cables,* ICEA/NEMA Pub. No. **WC 53-1983.**

Dear Representative:

Revision No. **1**, consisting of printed pages dated JULY 1987, is enclosed for insertion into your copy of the subject publication. Also enclosed is a new title page to indicate that your book now contains the revision.

To bring your copy of NEMA Publication No. WC 53-1983 up-to-date, please insert the attached revised pages in their proper places and delete the pages they replace.

Sincerely,

Krystyna A. McIver
Standards Publications Editor
NEMA

Encl: Revision No. **1** to WC 53-1983.
Copies to: All known holders of WC 53.

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icea / nema

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

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**NEMA WC 53-1983**

# WC 53

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

Revision 1—July 1987

*Published by*
**National Electrical Manufacturers Association**
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## 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 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 P, 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.



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## 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 which 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/WC3 (Rubber Insulated Wires & 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 Table 4. 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 the 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:



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| From | To | Multiplier |
|---|---|---|
| inches (in) | millimeters (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



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

## Section 1
## ELECTRICAL METHODS

### 1.1 CONDUCTOR DIRECT-CURRENT RESISTANCE

Direct current resistance shall be determined on a sample of any length, a foot or longer. When the nominal resistance of the sample is 1 ohm or more, the procedure in 1.1.1 shall be followed. When the nominal resistance of the sample is less than 1 ohm, the procedure in 1.1.2 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 1.1.2 and precautions in 1.1.3 shall be followed.

#### 1.1.1 Method When Sample Nominal Resistance is 1 Ohm or More

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

#### 1.1.2 Method When Sample Nominal Resistance is Less Than 1 Ohm

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

#### 1.1.3 Precautions for Short Sample Method

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

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

**1.1.3.2** 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 1.1.3.4

**1.1.3.3** The distance between potential electrodes shall be measured to an accuracy of $\pm 0.05$ percent. To assure this accuracy in measuring the length between potential contacts, the surface in contact with the test specimen shall be a substantially sharp knife edge.

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

**1.1.3.5** 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.

**1.1.3.6** 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

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potential contacts shall be the same to minimize imbalanced contact potentials. If necessary, the contact surfaces shall be cleaned.

### 1.1.4 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 1 or the procedure in ASTM B 193 shall be used.

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

| Temperature Degrees, 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 |

The conversion factors given in Table 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 formulae:

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

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

Where: $R_1$ = Resistance at 25°C
$R_2$ = Measured Resistance at Temperature $T_2$

For more accurate determination of resistance, allowing for different 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.

## 1.2 VOLTAGE WITHSTAND

The voltage which an insulated conductor is required to withstand shall be applied, in accordance with 1.2.1 or 1.2.2, between the insulated conductor and the specified ground.

### 1.2.1 An Alternating Current Voltage

An alternating current voltage having a frequency of 55 ± 6 Hz, not greater than the rated alternating current 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.

### 1.2.2 A Direct Current Voltage

A direct current voltage, not greater than 3.0 times the rated alternating current 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.

## 1.3 INSULATION RESISTANCE

The test apparatus shall be in accordance with ASTM D 257. Measurements shall be taken according to 1.3.1 or 1.3.2. 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 direct current voltage of 300 ± 200 volts.

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### 1.3.1 Single Conductor Cables

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

### 1.3.2 Multiple Conductor Cables

#### 1.3.2.1 Nonshielded Cables

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

#### 1.3.2.2 Shielded Cables

Measurements shall be taken between the conductor and cable shield.

### 1.3.3 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 which 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 five 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 3.1.

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 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 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.

### 1.3.4 Converting Insulation Resistance to Insulation Resistance Constant

The measured 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:

$$IR = (IRK) \cdot \log_{10} (D/d)$$

Where:

IR = Insulation resistance in megohms − 1000 feet, at 15.6°C

IRK = Insulation resistance constant in megohms − 1000 feet

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.

## 1.4 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.

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## Table 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 | 3.03 | 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.

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

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

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.

## 1.5 SPARK TESTING

Use of spark test equipment to evaluate irregularities of jackets over metal components is covered in paragraph 3.8.

### 1.5.1 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 earthground. 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 ⅜ inch but a spacing of ½ inch is acceptable if the transverse rows of chain are staggered.

The electrode shall be provided with an earth-grounded 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.

### 1.5.2 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.

The conductor, cable shield, sheath or armor, as applicable, of the cable shall be earth-grounded during the spark test. An earth-ground 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 earth-ground connection need be made at only one point—at either the take-up or pay-off reel. In any case, a reel at which an earth-ground connection is made shall be bonded directly to the earth-ground on the potential source of the spark tester.

## 1.6 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 ft. 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.

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*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 1.7 shall be made on each test specimen after a total immersion period of 1 day, 1 week, 2 weeks, 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 1.7.

## 1.7 THE EM-60 ACCELERATED WATER ABSORPTION METHOD

The cable sample shall be at least 15 feet long. The middle 10 feet of the cable sample shall be immersed in tap water which is maintained at 75 ± 1°C for a period of 14 days, keeping 2.5 ft. at each end above water as leakage insulation. A tightly fitting cover shall be placed directly above the water surface, with suitable watertight bushings for the ends of the sample. 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 sress 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 75 ± 1°C for the specified time. The alternate to stability factor is the stability factor at the specified time minus stability factor at one day.

## 1.8 PERMITTIVITY AND VOLTAGE WITHSTAND FOR NONCONDUCTING STRESS CONTROL LAYERS

The sample shall be a 18 ± 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 used. Following the permittivity determination and while the specimen is kept at the specified temperature, a 60 Hz alternating current 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 conrol layer, in inches

## 1.9 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 which was immersed. A 375 ± 125 volt direct-current 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 be 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

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## 1.10 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 or more than 45 minutes following the bending, a source of 60 Hz alternating-current potential at the specified voltage shall be applied between the conductor and the metal plate continuously for the specified time and temperature.

*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 I. J. Marwick.

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## 1.11 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 5½ 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 insulated 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 which 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.

*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 which 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 ten cycles and a maximum of fifty 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.

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# Section 2
# DIMENSIONAL METHODS

## 2.1 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.

## 2.2 THICKNESS OF COMPONENTS OVER A CONDUCTOR

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

### 2.2.1 Optical Measuring Device Method for Any Component

The thickness 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.

### 2.2.2 Micrometer Method for Unbonded Components

The thickness of any 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:

#### 2.2.2.1 Extruded Insulation Shield or Jacket

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

#### 2.2.2.2 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.

##### 2.2.2.2.1 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.

##### 2.2.2.2.2 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 six inches of core or cable.

#### 2.2.2.3 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.

#### 2.2.2.4 Sheath

Thickness shall be the average of ten 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.

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## 2.3 DIAMETERS OVER CABLE COMPONENTS

### 2.3.1 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 in the outer layer which are 180 degrees apart. The average of three measurements taken 120 degrees apart shall be taken as the diameter.

*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.

### 2.3.2 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.

### 2.3.3 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.

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# Section 3
# PHYSICAL METHODS

## 3.1 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 half 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 as possible to 90 degrees throughout the test.

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

## 3.2 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.

## 3.3 HEAT DEFORMATION (DISTORTION)

### 3.3.1 Insulation Deformation

#### 3.3.1.1 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 insulation 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 ± 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 ⅜ inch diameter foot with no loading other than the 85 grams of the gauge.

#### 3.3.1.2 Test Procedure

The following steps shall be completed in 3 hours. A Randall & Stickney, or equivalent, gauge with a load as indicated in Table 3 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 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:

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

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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.

#### 3.3.1.3 Calculation of Deformation

The deformation shall be calculated as follows:

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

**Table 3**
**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 |

### 3.3.2 Deformation of Jackets, Insulating and Conducting

#### 3.3.2.1 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.

#### 3.3.2.2 Test Procedure

The following steps shall be 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.

#### 3.3.2.3 Calculation of Deformation

The deformation shall be calculated as follows:

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

### 3.4 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.

### 3.5 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.

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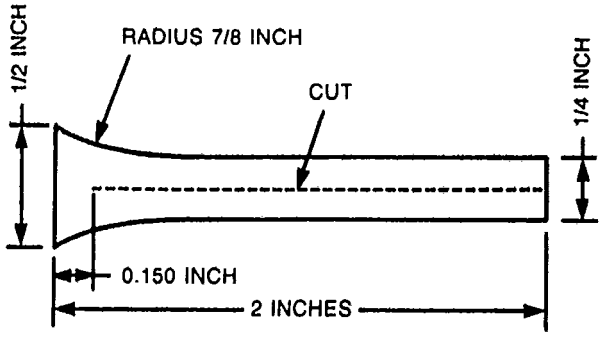


**TEST SPECIMEN FOR TEAR TEST**

## 3.6 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 millimeters 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 times the diameter of the sample, and the ends shall be inserted in tightly fitting holes in the cover of a 16 ounces (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 which 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 millimeters 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.

## 3.7 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.

## 3.8 JACKET IRREGULARITY INSPECTION

**3.8.1** Three methods for Jacket Irregularity Inspection are indicated in Table 4. 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 paragraph 1.5, Spark Testing.

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

**Table 4**
**JACKET IRREGULARITY INSPECTION**

| Thickness of Jacket | | Method A | Method B ac Spark Testing Voltage | Method C |
|---|---|---|---|---|
| mils | mm | | kV | kV |
| 45 | 1.14 | Visual | 2.0 | 4.0 |
| 50 | 1.27 | Inspection | 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 |

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**3.8.2** 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.

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## Section 4
## INDUSTRY STANDARDS REFERENCED IN THIS DOCUMENT

ASTM B 193-78
Resistivity of Electrical Conductor Materials, Test for

ASTM D 257-78
DC Resistance of Conductance of Insulating Materials, Test for

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)

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

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

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September 1984

# NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted 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 its particular need. 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.

*(Bylaw—Art. V, Sec. 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.

*(Bylaw—Art. V, Sec. 2, Subsection A)*

## 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.

*(NEMA Policy Memorandum 84-2, dated June 7, 1984)*

## Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product 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.

*(Bylaw—Art. V, Sec. 2, Subsection B)*

## 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.

*(Bylaw—Art. V, Sec. 6, 1st Sentence)*

## 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.

*(Bylaw—Art. V, Sec. 4, Subsection A)*

## 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.

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