UL 1441

STANDARD FOR SAFETY

Coated Electrical Sleeving

UL Standard for Safety for Coated Electrical Sleeving, UL 1441

Fifth Edition, Dated June 21, 2021

Summary of Topics

This revision of ANSI/UL 1441 dated October 28, 2022 is issued to remove redundant information in 5.7.1 and to revised 5.8.3 to remove "not-heat-shrinkable".

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated August 19, 2022.

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CSA Group
CSA C22.2 No. 198.3:21
Third Edition

Underwriters Laboratories Inc.
UL 1441
Fifth Edition

Coated electrical sleeving

June 21, 2021

(Title Page Reprinted: October 28, 2022)

Approved American National Standard

ANSI/UL 1441-2022

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as "CSA Group") and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

ISBN 978-4-4883-2529-8 © 2021 Canadian Standards Association

This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through October 28, 2022.

The most recent designation of ANSI/UL 1441 as an American National Standard (ANSI) occurred on October 28, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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Preface

This is the harmonized CSA Group and UL standard for Coated Electrical Sleeving. It is the third edition of CSA C22.2 No. 198.3 and the fifth edition of UL 1441. This edition of CSA C22.2 No. 198.3 supersedes the previous edition(s) published published in 1995 and 2005. This edition of UL 1441 supersedes the previous edition published on November 27, 2018. This harmonized standard has been jointly revised on October 28, 2022. For this purpose, CSA Group and UL are issuing revision pages dated October 28, 2022.

This harmonized standard was prepared by the CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee 15C (Electrical Tubing and Sleeving Products) of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA) are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Insulation Systems, under the jurisdiction of the CSA Technical Committee on Wiring Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it to be considered equivalent to, an IEC standard.

This standard is published as an equivalent standard for CSA and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The Technical Harmonization Subcommittee identified the following standard as being within the scope of this standard: IEC 60684, Flexible Insulating Sleeving. IEC 60684 and UL 1441/CSA C22.2 No. 198.3 are similar but not identical. Both standards cover multiple, but not identical, products and similar methods. The THC agreed to address the issues involved in the harmonization of these standards during the next revision of UL 1441/CSA C22.2 No. 198.3.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

Coated electrical sleeving

1 Scope

1.1 The requirements of this Standard apply to Grades A and B acrylic-polymer-coated, silicone-polymer-coated, or vinyl-polymer-coated electrical sleeving that consists of closely woven fabric made from glass (see Table 1 for materials and ratings) and intended for use in equipment designed to be installed and used in accordance with the rules of CSA C22.1, Canadian Electrical Code, Part I, (CE Code, Part 1), or ANSI/NFPA 70, National Electrical Code (NEC). A product for use at temperatures greater than indicated in 1.2 or a different polymer coating or fiber may be acceptable provided that

(a) it meets the performance tests in this Standard; and

(b) long-term heat-aging tests are conducted as covered in UL 746B or CAN/CSA-C22.2 No. 0.17, using dielectric strength as a primary property and flammability as a secondary property.

1.2 These requirements apply to coated electrical sleeving having a standard temperature index classification of 105, 130, 155, 180, 200, 220, and 240 °C.

1.3 These requirements apply to coated electrical sleeving intended for use in connection with the internal wiring of electrical devices and appliances located in dry or damp locations where it is not feasible to employ a standard insulated conductor, such as appliance wiring material, specifically intended for the purpose. Coated electrical sleeving is intended for insulating one or more uninsulated or partially insulated conductors, bus bars, component leads, or assemblies of electrical components. Coated electrical sleeving may be employed in equipment where it is not subjected to repeated flexing or severe mechanical stress.

1.4 These requirements apply to oil-resistant coated electrical sleeving intended for occasional or intermittent contact with oil.

1.5 These requirements do not apply to unimpregnated or uncoated fabric sleeving, which is generally not considered acceptable for sole (functional) insulation because of the openings inherent in the weave construction of the sleeving fabric.

1.6 These requirements do not apply to tubing extruded with reinforcement, extruded electrical tubing, or tubing intended only for mechanical protection, since they are covered by other requirements.

1.7 These requirements do not apply to coated electrical sleeving when it is employed as splice insulation in an insulation system above 105 °C (Class A) operation.

2 Reference publications and definitions

2.1 Reference publications

For undated references to standards, such reference shall be considered to refer to the latest edition and all revisions to that edition up to the time when this Standard was approved.

For dated references to standards, such reference shall be considered to refer to the dated edition and all revisions published to that edition up to the time the standard was approved.

CSA (Canadian Standards Association)

C22.1:18
Canadian Electrical Code, Part I

CAN/CSA-C22.2 No. 0.17-00
Evaluation of Properties of Polymeric Materials

CSA C22.2 No. 2556:15 (R2020)
Wire and cable test methods

UL (Underwriters Laboratories Inc.)

UL 746B
Standard for Polymeric Materials – Long Term Property Evaluations

UL 1581
Reference Standard for Electrical Wires, Cables, and Flexible Cords

UL 2553
Wire and Cable Test Methods

ANSI/NFPA (American National Standards Institute/National Fire Protection Association)

NFPA 70-2005
National Electrical Code

ASTM (American Society for Testing and Materials)

ASTM D 257-99
Standard Test Methods for DC Resistance or Conductance of Insulating Materials

ASTM D 350-01
Standard Test Methods for Flexible Treated Sleeving Used for Electrical Insulation

ASTM D 2671-00
Standard Test Method for Heat-Shrinkable Tubing for Electrical Use

ASTM D 5025-99
Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials

ASTM D 5207-03
Standard Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials

ASTM D 5423-93 (1999)
Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

2.2 Definitions

2.2.1 For the purposes of this standard, the following definitions apply.

2.2.2 Coated electrical sleeving – a sleeving base that is coated with an electrical insulating material that completely covers the fabric interstices and is then cured.

2.2.3 Sizing – a compound that, when applied to sleeving, forms a more or less continuous film around the individual fibers.

3 General requirements

The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only, except for conductor sizes where the equivalent metric values are in parentheses.

4 Construction

4.1 General

4.1.1 The coated electrical sleeving shall be made with the degree of uniformity and quality of work that are practicable in a well-equipped factory.

4.1.2 The sleeving base shall be made from closely woven fibers or monofilaments that may or may not employ a sizing agent.

4.1.3 The surface of the coated electrical sleeving shall be relatively smooth and free from blisters, cracks, and other defects that can be detrimental to the coated electrical sleeving in its intended use.

4.1.4 The acceptability of the coated electrical sleeving in any particular device or appliance depends on the conditions that prevail in actual service. Accordingly, for a particular application, the coated electrical sleeving will in some cases be affected by the requirements for the device or appliance in which the sleeving will be used, and it will be necessary to employ a coated electrical sleeving having features other than, or in addition to, those specified in these requirements. For example, coated electrical sleeving may be required to have a heavier wall thickness or a cross-section other than round; or it may be required to have an inherent resistance to the effects of immersion in water, oil, solvents, or other liquids or their vapours; or it may be required to be resistant to the development of fungi and similar organisms.

4.1.5 Sleeving may be of intermediate sizes, providing such sleeving complies with the minimum thickness requirement for the next larger size of sleeving.

4.1.6 Coated electrical sleeving designated as Grade A shall meet the following requirements:

(a) a 7000 V minimum average of 10 readings and a 5000 V minimum individual dielectric breakdown after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ± 5 percent relative humidity; and

(b) a 2200 V minimum average of 10 readings dielectric breakdown after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity.

4.1.7 Coated electrical sleeving designated as Grade B shall meet the following requirements:

(a) a 4000 V minimum average of 10 readings and a 2500 V minimum individual dielectric breakdown after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and

(b) a 1600 V minimum average of 10 readings dielectric breakdown after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity.

4.2 Physical dimensions

4.2.1 General

Coated electrical sleeving in Grades A and B shall be acceptable in the sizes referenced in Table 2. See also 4.1.5.

4.2.2 Inside diameter

4.2.2.1 The inside diameter of the coated electrical sleeving shall comply with Table 2. The inside diameter shall be measured in accordance with ASTM D 350.

4.2.2.2 The inside diameter of the coated electrical sleeving shall be determined by passing the minimum gauge rod for the size of sleeving under test into the specimen for a distance of 130 mm (5 in). If the rod has a snug fit, the specimen shall be considered to have an inside diameter equal to the diameter of the rod. If the minimum gauge rod fits loosely, the maximum gauge rod shall be inserted into the specimen. If the maximum gauge rod passes freely into the specimen for a distance of 130 mm (5 in) with a snug fit, or if it expands the wall of the specimen, the sleeving shall be considered to be of that size which falls within the limits of the maximum and minimum inside diameters as represented by the gauge rods.

4.2.3 Wall thickness

The wall thickness of the coated electrical sleeving shall not be less than as specified in Table 2. For all coated electrical sleeving, measurements of the minimum thickness of insulation shall be made in accordance with ASTM D 350 or by means of a dead-weight pin gauge dial micrometer that is equipped with a flat, rectangular presser foot that is 1.09 mm (0.043 in) by 7.92 mm (0.312 in). The pin shall be 1.09 mm (0.043 in) in diameter and 11.10 mm (0.437 in) long. The presser foot shall exert a force of 0.25 ±0.02 N (0.056 ±0.0045 lbf) on the specimen. The specimen shall be hung on the pin carefully so that the entire length of the presser foot makes contact with the specimen. The presser foot shall be brought to rest gently on the specimen and the reading shall be taken immediately. It is necessary to rotate the specimen and to make several measurements to determine the actual minimum thickness. In no case shall the presser foot be in contact with the specimen while the specimen is being rotated. As a referee method, an optical device measuring to an accuracy of 0.025 mm (0.001 in) may be used.

5 Tests

5.1 Pre-Conditioning and Test Conditions

5.1.1 Unless otherwise specified all testing, except flammability, should be conducted at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10%. Flammability testing shall be conducted in still air at a temperature of 15 – 35°C (59 – 95°F) and a relative humidity of < 75%. All samples shall be preconditioned at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10% for a minimum of 30 minutes prior to test.

5.2 Specimens

5.2.1 A complete set of specimens shall be tested as scheduled in Table 3 and Table 4.

5.2.2 If the coated electrical sleeving is to be considered in a range of colors, specimens representing those ranges shall be tested. If the performance characteristics are essentially the same, specimens in the most heavily pigmented light and dark colors shall be tested and considered representative of the color range. If the performance characteristics are not essentially the same for all specimens representing the

range, evaluation shall be limited only to the coated electrical sleeving in the colors tested, unless additional specimens in intermediate colors are tested.

5.3 Dielectric breakdown

5.3.1 Dielectric breakdown tests shall be conducted on specimens of size 12 AWG (2.16 mm) coated electrical sleeving that shall be placed on a straight length of size 12 AWG (4.21 mm^2) solid copper wire, about 150 mm (6 in) long, in such a manner that one end of the wire is exposed. Each specimen shall be bent for a quarter turn around a smooth right-circular mandrel having a diameter of 10 times the nominal inside diameter of the sleeve, 21.6 ±0.10 mm (0.850 ±0.004 in) for size 12 AWG (2.16 mm) coated electrical sleeving. The bend shall be so arranged that it is centrally located on the sleeving specimens.

5.3.2 Ten specimens shall be tested after exposure for a minimum of 40 hours at 23.0 ±2 °C (73.4 ±3.6 °F) at 50 ±5 percent relative humidity. A second set of 10 samples shall be tested after exposure for a minimum of 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) at 90 ±5 percent relative humidity. A separate set of specimens of Grade A coated acrylic, silicone polymer, and vinyl polymer glass-fiber sleeving shall be aged in an ASTM D 5423 Type 2 circulating-air oven at the temperature specified in Item 8 of the applicable table for Grade A sleeving. All specimens that were oven conditioned shall be exposed for a minimum of 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) at 50 ±5 percent relative humidity prior to testing. All specimens shall be tested at 23.0 ±2.0 °C (73.4 ±3.6 °F) at 50 ±5 percent relative humidity.

5.3.3 In addition to the requirements of 5.3.1 and 5.3.2, for a temperature index above the maximum shown for Grade A sleeving in the tables, or for Grade B or flame-retardant acrylic sleeving, long-term thermal aging tests shall be conducted in an ASTM D 5423 Type 2 circulating-air oven at the temperature specified in Item 8 of the applicable table. The rated temperature shall be determined from relative thermal index test in accordance with UL 746B or CAN/CSA-C22.2 No. 0.17 using dielectric breakdown as a primary property and flammability as a secondary property. See Table 4 for sample requirements.

5.3.4 After conditioning, a strip of aluminum foil that is approximately 25 mm (1 in) wide and 50 mm (2 in) long shall be wrapped around the bend in the test specimen. An alternating voltage potential shall be applied to the specimen, in air, between one end of the exposed copper wire and the aluminum foil. The voltage shall be started at zero and increased at a rate of 500 V/s until breakdown occurs.

5.3.5 The average breakdown voltage for unaged specimens shall not be less than the values indicated in Item 7 of the applicable tables.

5.3.6 The average breakdown voltage for aged specimens shall be at least half the average breakdown voltage for unaged specimens but not less than the values indicated in Item 9 of the applicable table.

5.4 Oil resistance

5.4.1 The coated electrical sleeving shall be considered oil resistant at 60 °C (140 °F) if after being subjected to the test described in 5.4.2, the average dielectric breakdown strength is at least 50 percent of the initial value, with any individual dielectric breakdown potential being not less than 1250 V for Grades A and B sleeving.

5.4.2 Five specimens shall be placed on a straight length of size 12 AWG (4.21 mm^2) solid copper wire, with one end of the wire exposed, and then bent for a quarter turn around a smooth right-circular mandrel having a diameter of 21.6 ±0.10 mm (0.850 ±0.004 in). Specimens shall then be immersed in IRM oil No. 902 for 96 hours at 100.0 ±1 °C (212.0 ±1.8 °F), and then removed from the oil, wiped with a soft clean cloth, and left at room temperature for approximately 1 hour before testing is continued. All specimens shall be exposed to a temperature of 23.0 ±2.0 °C (73.4 ±3.6 °F) at 50 ±5 percent relative humidity for a minimum of 40 hours. The remaining steps in the dielectric procedure shall be as described in 5.3.4.

5.4.3 The coated electrical sleeving shall be considered oil resistant at 80 °C (176 °F) if after being subjected to the test described in 5.4.4, the average dielectric breakdown strength is at least 50 percent of the initial value with any individual dielectric breakdown voltage being not less than 1250 V for Grades A and B sleeving.

5.4.4 Five specimens shall be placed on a straight length of size 12 AWG (4.21 mm^2) solid copper wire, with one end of the wire exposed, and then bent for a quarter turn around a smooth right-circular mandrel having a diameter of 21.6 ±0.10 mm (0.850 ±0.004 in). Specimens shall then be immersed in IRM oil No. 902 for 60 days at 80.0 ±1.0 °C (176.0 ±1.8 °F), and then removed from the oil, wiped with a soft clean cloth, and left at room temperature for approximately 1 hour before testing is continued. All specimens shall be exposed to a temperature of 23.0 ±2.0 °C (73.4 ±3.6 °F) at 50 ± 5 percent relative humidity for a minimum of 40 hours. The remaining steps in the dielectric procedure shall be as described in 5.3.4.

5.5 Cold bend

5.5.1 Coated electrical sleeving shall not crack, either on the outer surface or internally, when wound at a uniform rate onto a metal mandrel at −10.0 ±1.0 °C (+14.0 ±1.8 °F). A conductor shall not be inserted in the sleeving during this test.

5.5.2 The test shall be made using three 250 mm (10 in) lengths of coated electrical sleeving that are cooled for 1 hour in a pre-cooled cold chamber to −10.0 ±1.0 °C (+14.0 ±1.8 °F). A right-circular metal mandrel having the diameter indicated in Table 5 shall be secured in the chamber and cooled to the low temperature at the same time as the specimen.

5.5.3 At the end of the hour of cooling, each specimen shall be wound onto the mandrel while both are maintained at the low temperature. The rate of winding shall be approximately 3 seconds per turn, and successive turns shall be in contact with one another. The specimen shall be wound for the number of turns indicated in Table 5. While the specimen is held tautly in place on the mandrel, the mandrel and specimen shall be removed from the cold chamber and the specimen examined using normal or corrected-to-normal vision. The sleeving shall not be acceptable if cracks develop either on the outer surface or internally. Internal cracks (checks) can often be detected by circumferential depressions in the outer surface of the sleeving.

5.6 Volume resistivity

5.6.1 Sleeving shall meet the requirement specified in Item 14 of Table 6 to Table 15, as applicable, when tested for volume resistivity.

5.6.2 Select three lengths of solid uninsulated copper wire or conductive mandrels (inner electrode) nominally 300 mm (12 in) long that have a smooth, uniform outer diameter and that provide a snug fit in the sleeving to be tested. Using a micrometer, determine the average outer diameter, D_1, of the center 150 mm (6 in) of the inner electrode at least 4 places along its length. The micrometer shall have a resolution of at least 0.01 mm (0.0004 in).

5.6.3 Three sleeving specimens, each with a nominal 250 mm (10 in) length of sleeving, shall each be slid over and centered on one of the selected inner electrodes. Using a micrometer, determine the average outer diameter, D_2, of the center 150 mm (6 in) of the sleeving at least 4 places along its length. Use a micrometer with a resolution of at least 0.01 mm (0.0004 in). Wrap a small gauge copper wire around the center of the sleeving so that it is snug but does not deform the sleeving. Apply a 150 mm (6 in) continuous-length conductive paint electrode (with well-defined edges) around the center of the sleeving and over and under the copper wire, leaving at least 25 mm (1 in) extending beyond the conductive paint at each end of the specimen (Figure 1). If a guarded electrode system is used, a longer mandrel and longer samples will in some cases be needed to allow for a 150 mm (6 in) main electrode. Allow the paint to dry thoroughly before testing the specimens.

5.6.4 Place each specimen in a non-conductive fixture that supports the ends of the specimen and keeps the center of the specimen from coming into contact with conductive surfaces. Connect the specimen to a calibrated high-resistance meter, megohmmeter, or other instrumentation that meets the requirements of ASTM D 257. Connect the negative lead to the inner electrode and the positive lead to the outer electrode (composed of the attached copper wire and conductive paint). Energize the sample using a direct applied voltage of 500 ± 5 V and measure the resistance, *Rv*, in ohms at the end of 60 seconds. Calculate the volume resistivity using the following formula:

$$\rho v = 0.2\pi L R_v / In(D_2 / D_1)$$

where:

ρv = volume resistivity, Ω·cm

L = length of the painted electrode, mm

R_v = measured volume resistance, ohms

D_1 = outer diameter of the inner electrode, mm (in)

D_2 = inner diameter of the outer electrode (the average sleeving outer diameter), mm (in)

5.7 Horizontal-specimen flame

5.7.1 A horizontal specimen of coated electrical sleeving shall not

(a) convey flame along its length; or

(b) convey flame to combustible materials in its vicinity

after a single 30 second application of a 225 W test flame (770 Btu/h) nominally 50 mm (2 in) high.

5.7.2 The gas flame produced by the burner (see 5.7.1) shall be calibrated as described in ASTM D 5207 with the following modifications to adapt the procedure for the 125 mm (5 in) flame to the 50 mm (2 in) flame:

(a) The copper slug used for the 125 mm (5 in) flame shall also be used for the 50 mm (2 in) flame. For the 50 mm (2 in) flame, the slug shall be positioned 25 mm (1 in) above the tip of the burner during the calibration procedure.

(b) The starting gas-flow rate for methane shall be 405 ±10 mL/min (0.1 gallon/min) with a back pressure of 45 ±5 mm water (1.8 ±0.2 in).

(c) The needle valve and air-inlet openings on the burner shall be adjusted until the overall height of the flame is 50 ±4 mm (2 ±0.16 in) and the height of the blue inner cone is 16.5 ±1.5 mm (0.65 ±0.06 in).

(d) The time for the temperature to rise from 100 to 700 °C (212 to 1292 °F) shall be 84 ±2 seconds.

The results of this test shall be judged as indicated in 5.7.8.

5.7.3 The test is to be conducted in a three-sided enclosure placed in the draft-free chamber described in Section 9.4 (FV-2/VW-1 test) in CSA C22.2 No. 2556 / UL 2556. The three-sided enclosure shall be 610 mm (24 in) wide, 305 mm (12 in) deep, and 305 mm (12 in) high. The top and front shall be open. The burner shall be placed directly on the floor of the enclosure. The testing surface (chamber floor or bench

top) shall be at least 1.2 m (4 ft) below the top of the chamber walls (at the transition to the exhaust). The dimensions of the testing surface of the bench are such in order to accommodate the rectangular layer of cotton described below. A specimen 610 mm (24 in) long cut from a sample length of the sleeving shall be centered on a 597 mm (23.5 in) straight length of solid conductor or steel rod having a diameter that snugly fits within the sleeving. The specimen shall be secured with its longitudinal axis horizontal. The specimen supports shall be 560 mm (22 in) apart, and three metal rods or equivalent permanent means whose free ends are no closer than 20 mm (3/4 in) to the specimen shall be used to indicate three points on the specimen measuring 51 mm (2 in), 178 mm (7 in), and 330 mm (13 in) from the left-hand point of support of the specimen. A flat, horizontal layer of dry (untreated), pure, surgical cotton not more than 6 mm (1/4 in) thick is to cover an area of the testing surface not less than 610 mm (24 in) long by 150 to 200 mm (6 to 8 in) wide, with the length centered on the horizontal axis of the test specimen. Cotton shall not be on or under the burner. No openings are permitted through the layer of cotton. The upper surface of the cotton shall be 230 to 240 mm (9 to 9-1/2 in) below the lower surface of the specimen (as shown in Figure 2).

5.7.4 Before each test and while the barrel is vertical and the burner is well away from the specimen, the gas flame shall be checked to make certain that its overall height is 50 ±4 mm (2 ±0.16 in) and that the blue inner cone is 17 ±1 mm (0.67 ±0.04 in) high, as established during calibration. A flame that changes from blue to luminous without any change of the settings is an indication that the fuel-gas content of the cylinder is exhausted and that the denser depletion-indicator material (propane, for example), which some suppliers add to their cylinders, is being burned instead. In this case, the cylinder is to be labelled as empty and then returned for refilling. Where the overall flame is blue and the height of the blue inner cone is other than 17 ±1 mm (0.67 ±0.04 in) without any change of the settings, the contents of the cylinder likely are at low pressure. A gas-supply gauge pressure of 69 to 138 kPa (10 to 20 lbf/in^2) has been found adequate to maintain the required flame. A cylinder shall not be used when this range of pressure is no longer sustainable at room temperature.

5.7.5 The burner shall be secured in an adjustable support jig with the longitudinal axis of the barrel vertical. The jig shall be positioned to place the longitudinal axis of the barrel in the vertical plane that intersects the specimen perpendicularly at the marker located 51 mm (2 in) or from the left-hand point of support of the specimen. The jig shall also be positioned to place the intersection of the longitudinal axis of the barrel and the plane of the tip of the barrel 16.5 ± 1.5 mm(11/16 ± 0.5 in) below the point, Point A, at which the extended longitudinal axis of the barrel meets the outer surface of the underside of the specimen at the 51 mm (2 in) marker. As shown in Figure 2, Point A is the point on the surface of the underside of the specimen at which the tip of the blue inner cone shall touch the specimen.

5.7.6 The support for the burner shall be arranged to enable the burner to be swung or slid into the position described in 5.7.5 and quickly removed. The motion of the burner is not to disturb the layer of cotton on the testing surface or result in the cotton coming away from the base of the burner.

5.7.7 The burner shall be supported as indicated in 5.7.6 in a position away from the specimen and then lit; where the burner has a gas pilot light, the pilot shall not be used. The lit burner shall be moved into position to apply the tip of the blue inner cone of its flame to the underside of the specimen at the 51 mm (2 in) marker (point A), kept there for 30 seconds, removed to a position well away from the specimen, and then extinguished by closing the gas supply valve. Note is to be taken and a record made of whether any flaming of the specimen progresses beyond the 178 mm (7 in) marker. Where flaming of the specimen passes this marker, the amount of time that the specimen flame takes to progress from the 178 mm (7 in) marker toward the 330 mm (13 in) marker is to be noted and divided into the total length of specimen burned between the 178 mm (7 in) and the 330 mm (13 in) markers. Note is also to be taken and a record made of whether particles or drops that ignite any of the cotton are emitted by the specimen during or after application of the gas flame.

5.7.8 Where any specimen flames at a rate greater than 25 mm/min (1 in/min) between the markers at 178 mm (7 in) and 330 mm (13 in), measured as described in 5.7.7, the coated electrical sleeving shall be judged capable of conveying flame along its length. Where any specimen emits flaming or glowing

particles or flaming drops at any time that ignite the cotton (flameless charring of the cotton is to be ignored), the coated electrical sleeving shall be judged capable of conveying flame to combustible materials in its vicinity. Where any specimen (at any time) emits flaming or glowing particles or flaming drops that fall outside the area of the testing surface covered by the cotton and/or that fall onto the burner, the test results shall be discarded and the test shall be repeated. For the repeat test, the rectangular layer of cotton shall cover an area of the testing surface 610 mm (24 in) long by 305 mm (12 in) deep centered on the horizontal axis of the specimen, and the specified cotton shall be clamped or otherwise secured around the base of the burner. Cotton shall not be under the burner. None of the cotton shall ignite in the repeat test nor shall the specimen flame at a rate greater than as specified in 5.7.8.

5.8 VW-1 (vertical-wire) flame (Optional)

Note: This test corresponds with ASTM D 2671, as modified in 5.8.

5.8.1 A vertical specimen of coated electrical sleeving that is identified as VW-1 shall not flame or glow longer than 60 seconds following any of the five 15 second applications of the test flame, the period between applications being

(a) 15 seconds if the specimen's flaming or glowing ceases within 15 seconds; or

(b) the duration of the specimen's flaming or glowing, if it persists longer than 15 second.

The specimen shall not ignite combustible materials in its vicinity or damage more than 25 percent of the indicator flag during, between, or after the five applications of the test flame. The test shall be conducted as described in 5.8.2 to 5.8.13.

5.8.2 This test shall be performed on unaged specimens of the coated electrical sleeving. The test shall be conducted in a three-sided metal enclosure in an exhaust hood or cabinet, described in Section 9.4 (FV-2/VW-1 test) in CSA C22.2 No. 2556 / UL 2556. The metal enclosure shall be 305 mm (12 in) wide, 355 mm (14 in) deep, 610 mm (24 in) high, and the top and front shall be open. The enclosure shall be equipped with means for supporting a 559 mm (22 in) straight length of coated electrical sleeving that is closed at one end to prevent a chimney effect and that is suspended vertically.

5.8.3 A 660 mm (26 in) length of coated electrical sleeving shall be drawn onto a wire 890 mm (35 in) in length. For coated electrical sleeving whose nominal inside diameter is at least 0.81 mm (0.032 in), a 0.74 mm (0.029 in) diameter fine spring-steel music wire shall be used. If the nominal inside diameter of the coated electrical sleeving is 0.44 to 0.81 mm (0.019 to 0.032 in), a 0.41 mm (0.016 in) diameter fine spring-steel music wire shall be used. If the nominal inside diameter of the coated electrical sleeving is less than 0.44 mm (0.019 in), a 0.25 mm (0.010 in) diameter fine spring steel music wire shall be used. The combination of the specimen and its supporting wire with its longitudinal axis vertical in the center of the enclosure shall be secured at one end to the middle of the upper support by kinking the coated electrical sleeving and clamping (using a paper clip or clamp) to provide a closed end to the specimen, thus preventing any chimney effects during the test. The lower end of the wire protruding from the open end of the coated electrical sleeving shall be passed over the middle of the lower support and secured.

5.8.4 A flat horizontal layer of untreated surgical cotton approximately 3 mm (1/8 in) thick shall cover the floor of the enclosure. The upper surface of the cotton shall be no more than 240 mm (9-1/2 in) below Point B, which is the point at which the tip of the blue inner cone of the test flame touches the specimen. (See Figure 3.)

5.8.5 A burner conforming to ASTM D 5025 having a bore of 9.5 ±0.3 mm and a length of 100 ±10 mm from the top of the air-inlet openings to the top of the mixing tube, or an equivalent that meets the calibration of ASTM D 5207, shall supply the flame. While the barrel is vertical and the burner is well away from the specimen, the overall height of the flame shall be adjusted to approximately 100 to 125 mm (4 to 5 in) and the blue inner cone shall be adjusted to a height 40 ±2 mm or 1-9/16 in high. Without disturbing

the adjustments for the height of the flame, the valve supplying gas to the burner flame and the separate valve supplying gas to any pilot flame shall be closed.

5.8.6 A wedge (acceptable dimensions are shown in Figure 4) to which the base of the burner can be secured shall be provided for tilting the barrel 20 degrees from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The burner shall be secured to the wedge, and the assembly shall be placed in an adjustable support jig. A layer of untreated surgical cotton approximately 3 mm (1/8 in) thick and 25 mm (1 in) in diameter shall be placed on the wedge and around the base of the burner. The jig shall be adjusted toward one side or the other of the enclosure to place the longitudinal axis of the barrel in the vertical plane that contains the longitudinal axis of the specimen. The plane shall be parallel to the sides of the enclosure. The jig shall also be adjusted toward the rear or front of the enclosure to position Point A, which is the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel, 38 mm (1-1/2 in) from Point B, the point at which the extended longitudinal axis of the barrel meets the outer surface of the specimen. Point B is the point at which the tip of the blue inner cone shall touch the center of the front of the specimen. The specimen shall be adjusted vertically to prevent Point B from being any closer than 76 mm (3 in) to the lower clamp or other support for the specimen. (See Figure 3.)

5.8.7 In the absence of a gas pilot light on the burner, the support for the burner and wedge shall be arranged to enable the burner to be quickly removed from and precisely returned to the position described in 5.8.6, without disturbing the layer of cotton on the floor of the enclosure or the cotton on the wedge around the base of the burner.

5.8.8 A strip of unreinforced 94 g/m^2 (60 lb) kraft paper that is 13 mm (1/2 in) wide, approximately 0.1 mm (5 mils) thick, and gummed on one side shall be used to make an indicator flag. The gumming shall be moistened just enough to facilitate adhesion. With the gum toward the specimen, the strip shall be wrapped around the specimen once, with its lower edge 254 mm (10 in) above Point B, the point at which the blue inner cone shall touch the specimen. The ends of the strip shall be pasted together evenly and trimmed to provide a flag that projects 19 mm (3/4 in) from the specimen toward the rear of the enclosure, with the flag parallel to the sides of the enclosure. (See Figure 3.)

5.8.9 If the burner has a gas pilot light, the valve supplying the gas to the pilot shall be opened and the pilot lit. If the burner does not have a gas pilot light, the burner shall be supported as indicated in 5.8.7 in a position away from the specimen and then lit.

5.8.10 The flame shall be applied to the specimen for 15 seconds and removed for 15 seconds (or longer if flaming or glowing of the specimen persists). This cycle shall be repeated a total of five times. If flaming or glowing of the specimen persists longer than 15 seconds after the previous application of the gas flame, the gas flame shall not be reapplied until flaming or glowing of the specimen ceases of its own accord. Either a gas burner with a pilot light having a valve supplying gas to the burner that can be turned on or off to apply the flame, or a burner without a pilot light that is moved into position to apply the flame, may be used. If the supporting wire breaks due to the flame, the sample shall be discarded and the test shall be repeated with a new specimen.

5.8.11 If any specimen of the coated electrical sleeving shows more than 25 percent of the indicator flag burned away or charred (soot that can be removed with a cloth or the fingers and brown scorching shall be ignored) after any of the five applications of flame, the coated electrical sleeving shall be considered capable of conveying flame along its length.

5.8.12 If any specimen of the coated electrical sleeving emits flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure (flameless charring of the cotton shall be ignored), the coated electrical sleeving shall be considered capable of conveying flame to combustible materials in its vicinity.

5.8.13 If any specimen of the coated electrical sleeving continues to flame or glow longer than 60 seconds after any application of the gas flame, the coated electrical sleeving shall be considered capable of conveying flame to combustible materials in its vicinity.

5.8.14 If only one of the three specimens tested failed to comply with the requirements, three additional specimens shall be tested. All three additional specimens shall comply with the requirements.

5.9 Hydrolytic stability (Stability under humidity)

5.9.1 Silicone-polymer-coated electrical sleeving shall not revert to its elemental constituents, become tacky, or flow or soften when tested as indicated in 5.9.2.

5.9.2 Three specimens of the sleeving (silicone-polymer-coated only) shall be suspended above 50 mL (1.7 oz) of distilled water in separate sealed test tubes. The sleeving shall be positioned in the test tube so as to prevent it from contacting the sides of the test tube and the water. The sealed tubes shall then be placed in an oven and maintained at 70.0 ±1.0 °C (158.0 ±1.8 °F) for 336 hours (14 days). After the conditioning period, the test tubes shall be removed from the oven and cooled to room temperature. The tubes shall then be opened and the silicone-polymer-coated electrical sleeving examined.

6 Marking

6.1 Product marking

Product marking shall not be required.

6.2 Package marking

All sizes of coated electrical sleeving shall be marked with the following or equivalent information on the outside of the spool, on a separate tag on each end of the sleeving, on the bundling wrapper, or on the outside of the smallest unit container:

(a) the organization responsible for the product (registered trademark, trade name, manufacturer's name, or other recognized symbol of identification of the manufacturer);

(b) catalogue number (or type number or other number used for distinguishing purposes) or (recognized) equivalent (or part number);

(c) temperature rating in °C;

(d) voltage rating;

(e) date of manufacture (or a lot number, if the date of manufacture can be traced from this number);

(f) flammability rating (if VW-1); and

(g) the oil-resistance identification "oil resistant 60 °C", (or 80 °C, as appropriate), if in compliance with the requirements of 5.4.

6.3 Factory identification

In the United States, if the manufacturer produces coated electrical sleeving in more than one factory, the marking described in 6.2 shall include a marking (which may be in code) by means of which the sleeving can be identified as the product of a particular factory.

In Canada, this requirement does not apply.

Table 1
Sleeving Covered By This Standard

(See 1.1.)

Coating material	Temperature rating	Voltage rating	Grade	Table
Polyvinyl chloride	105 °C (221 °F)	600 V	A	Table 6
Polymer	130 °C (266 °F)	600 V	A	Table 7
Polyvinyl chloride	Determined from thermal aging test	300 V	B	Table 8
Acrylic	155 °C (311 °F)	600 V	A	Table 9
Polymer	180 °C (356 °F)	600 V	A	Table 10
Acrylic	Determined from thermal aging test	300 V	B	Table 11
Silicone polymer	200 °C (392 °F)	600 V	A	Table 12
Silicone polymer	220 °C (428 °F)	600 V	A	Table 13
Silicone polymer	240 °C (464 °F)	600 V	A	Table 14
Silicone polymer	Determined from thermal aging test	300 V	B	Table 15

Table 2
Standard Trade Sizes for Flexible Coated Electrical Sleeving

(See 4.2.1, 4.2.2.1, and 4.2.3 and Table 6 – Table 15.)

Trade size		Inside diameter, Grades A and B				Minimum overall wall thickness			
		Maximum		Minimum		Grade A		Grade B	
AWG/in	mm	mm	in	mm	in	mm	in	mm	in
24 AWG	0.559	0.69	0.027	0.51	0.020	0.279	0.011	0.18	0.007
22	0.686	0.81	0.032	0.64	0.025	0.330	0.013	0.18	0.007
20	0.864	0.99	0.039	0.81	0.032	0.330	0.013	0.18	0.007
19	0.965	1.12	0.044	0.91	0.036	0.330	0.013	0.18	0.007
18	1.067	1.25	0.049	1.02	0.040	0.381	0.015	0.18	0.007
17	1.19	1.37	0.054	1.14	0.045	0.381	0.015	0.18	0.007
16	1.34	1.55	0.061	1.30	0.051	0.381	0.015	0.18	0.007
15	1.50	1.70	0.067	1.45	0.057	0.381	0.015	0.18	0.007
14	1.68	1.88	0.076	1.63	0.064	0.381	0.015	0.18	0.007
13	1.93	2.08	0.082	1.83	0.072	0.381	0.015	0.18	0.007
12	2.16	2.31	0.091	2.06	0.081	0.381	0.015	0.18	0.007
11	2.41	2.6	0.101	2.31	0.091	0.457	0.018	0.23	0.009
10	2.69	2.8	0.112	2.6	0.102	0.457	0.018	0.23	0.009
9	3.00	3.2	0.124	2.9	0.114	0.457	0.018	0.23	0.009
8	3.38	3.6	0.141	3.3	0.129	0.457	0.018	0.23	0.009
7	3.76	4.0	0.158	3.7	0.144	0.457	0.018	0.23	0.009
6	4.22	4.5	0.178	4.1	0.162	0.508	0.020	0.28	0.011
5	4.72	5.0	0.198	4.6	0.182	0.508	0.020	0.28	0.011
4	5.28	5.7	0.224	5.2	0.204	0.508	0.020	0.28	0.011
3	5.94	6.3	0.249	5.8	0.229	0.508	0.020	0.28	0.011

Table 2 Continued on Next Page

Table 2 Continued

Trade size		Inside diameter, Grades A and B				Minimum overall wall thickness			
		Maximum		Minimum		Grade A		Grade B	
AWG/in	mm	mm	in	mm	in	mm	in	mm	in
2	6.68	7.1	0.278	6.6	0.258	0.508	0.020	0.28	0.011
1	7.47	7.9	0.311	7.3	0.289	0.508	0.020	0.28	0.011
0	8.38	8.8	0.347	8.3	0.325	0.635	0.025	0.43	0.017
3/8 in	9.53	10.1	0.399	9.5	0.375	0.635	0.025	0.43	0.017
7/16	11.1	11.7	0.462	11.1	0.438	0.635	0.025	0.43	0.017
1/2	12.7	13.3	0.524	12.7	0.500	0.635	0.025	0.43	0.017
5/8	15.9	16.6	0.655	15.9	0.625	0.635	0.025	0.43	0.017
3/4	19.1	20.0	0.786	19.1	0.750	0.635	0.025	0.43	0.017
7/8	22.2	23.1	0.911	22.2	0.875	0.635	0.025	0.43	0.017
1	25.4	26.3	1.036	25.4	1.000	0.635	0.025	0.43	0.017

Table 3
Specimens for Investigation for Coated Electrical Sleeving[a]

(See 5.2.1.)

Test	Trade size AWG/in (mm)	Quantity	Specimen length	
			mm	in
Physical dimensions[b]	24 AWG, 3/8 in, and 1 in (0.559, 9.53 and 25.4)	5 each	180	7
Dielectric breakdown[b]	12 AWG (2.16)	10 unaged, 50 aged[c]	150	6
Oil resistance[b] (optional)	12 AWG (2.16)	5 unaged 5 aged	150	6
Cold bend[b]	12 AWG (2.16)	3	250	10
Volume resistivity[b]	12 AWG (2.16)	10	250	10
Horizontal flammability	24 AWG, 3/8 in, and 1 in (0.559, 9.53 and 25.4)	3 each	590	23
VW-1 flammability[b] (optional)	24 AWG, 3/8 in, and 1 in (0.559, 9.53 and 25.4)	3 each	660	26
Hydrolytic stability[b] (silicone only)	12 AWG (2.16)	3	150	6

[a] *This table covers Grade A vinyl polymer, silicone polymer, and acrylic types of coated electrical glass-fibers sleeving. For all other types of coated electrical sleeving, refer to Table 4.*

[b] *Specimens in the highest pigment loading of a light color such as white, and a dark color such as black, shall be investigated and considered representative of the color range. See 5.2.2.*

[c] *Manufacturers shall supply corresponding quantities and lengths of 4.21 mm^2 (12 AWG) solid copper wire. Manufacturers shall also place the sleeving onto the wire and bend the wire and sleeving to a 90 degree angle according to the procedure outlined in 5.3.1.*

Table 4
Specimens for Long-Term Thermal Aging Investigation for Coated Electrical Sleeving

(See 5.2.1 and 5.3.3 and Table 3.)

Property specimens	Method	Specimen size	Specimens per set	Sets	For each temperature	For all temperatures	For initial tests	Total
					Specimens	Specimens	Specimens	
Dielectric[a] breakdown	90° bend	150 mm (6 in) length of 12 AWG (2.16 mm)	10	9	90	360[b]	20[b]	380
Flammability[a]	Horizontal or VW-1 (optional)	660 mm (26 in) length of 24 AWG (0.559 mm)	3	3	9	9	5	14[c]
		660 mm (26 in) length of 3/8 in (9.53 mm) trade size	3	3	9	9	5	14[c]
		660 mm (26 in) length of 1 in (25 mm) trade size	3	3	9	9	5	14[c]

[a] *Specimens in the highest pigment loading of a light color such as white, and a dark color such as black, shall be investigated and considered representative of the color range. (See 5.2.2.)*

[b] *Half of the specimens shall be tested after conditioning for a minimum of 40 hours at 23.0 ±2 °C (73.4 ±3.6 °F) at 50.0 ±5 percent relative humidity. The remaining specimens shall be conditioned for a minimum of 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) at 95.0 ±5 percent relative humidity.*

[c] *Specimens shall be conditioned for a minimum of 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) at 50.0 ±5 percent relative humidity after aging and prior to testing.*

Table 5
Cold Bend Test

(See 5.5.2 and 5.5.3 and Table 6 – Table 15.)

Trade size, AWG/in	Maximum acceptable mandrel diameter		Number of complete turns around mandrel
	mm	in	
24 AWG	3.20	0.126	6
22	3.58	0.141	6
20	4.37	0.172	6
19	4.78	0.188	6
18	5.16	0.203	6
17	5.56	0.219	6
16	5.94	0.234	6
15	6.35	0.250	6
14	7.95	0.313	6
13	8.74	0.344	6
12	9.53	0.375	6
11	11.91	0.469	6
10	14.30	0.563	6
9	15.88	0.625	6

Table 5 Continued on Next Page

Table 5 Continued

Trade size, AWG/in	Maximum acceptable mandrel diameter		Number of complete turns around mandrel
	mm	in	
8	17.48	0.688	6
7	24.61	0.969	6
6	31.75	1.250	6
5	33.35	1.313	6
4	34.93	1.375	6
3	37.31	1.469	6
2	38.70	1.524	6
1	68.28	2.688	6
0	73.03	2.875	6
3/8 in	85.73	3.375	6
7/16	86.13	3.391	6
1/2	87.33	3.438	1/2
5/8	90.09	3.547	1/2
3/4	8[a]	8[a]	1/2
7/8	8[a]	8[a]	1/2
1	10[a]	10[a]	1/2

[a] *The actual outside diameter of a specimen (measured) shall be multiplied by 8 or 10 as indicated to determine to the nearest 0.025 mm (0.001 in) the diameter of the mandrel that is to be used. The diameter of the mandrel used shall be within 0.025 mm (0.001 in) of the calculated diameter.*

Table 6
Requirements for 600 V Grade A Vinyl-Coated Glass-Fiber Sleeving Rated 105 °C (221 °F)

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Polyvinyl chloride or a copolymer of vinyl chloride on glass fiber
2. Temperature rating	105°C (221°F)
3. Voltage rating	600V
4. Sizes	24 AWG (0.559 mm) – 1.0 in (25.4 mm) (See Table 2)
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	7000 V minimum average, with no individual value below 5000 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 2200 V minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	7 days at 175 ±1.0 °C (347.0 ±1.8 °F) and 60 days at 145.0 ±1.0 °C (293.0 ±1.8 °F)
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens but not less than 3500 V
10. Cold bend test	No cracking of specimens cooled for 1 hour at –10.0 ±1.0 °C (14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5

Table 6 Continued on Next Page

Table 6 Continued

Item	Information[a]
11. Horizontal-specimen flame test	See 5.7
12. VW-1 flame test (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{10}Ω·cm
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 7
Requirements for 600 V Grade A Polymer-Coated Glass-Fiber Sleeving Rated 130 °C (266 °F)

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Polymer of glass fiber
2. Temperature rating	130°C (266°F)
3. Voltage rating	600 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2)
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	7000 V minimum average, with no individual value below 5000 V after being conditioned for 40 hours at 23.0 ± 2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 2200 V minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	Accelerated thermal aging; suggested temperatures 180, 170, 160, and 150 °C (356, 338, 320, and 302 °F) in accordance with UL 746B or CAN/CSA-C22.2 No. 0.17, using Grade A vinyl-coated glass-fiber sleeving as a control material with an established relative thermal index
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens, but not less than 3500 V
10. Cold bend test	No cracking of specimens cooled for 1 hour at –10.0 ±1.0 °C (+14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5
11. Horizontal-specimen flame test	See 5.7
12. VW-1 flame test (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{10} Ω·cm (minimum)
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 8
Requirements for 300 V Grade B Vinyl-Coated Glass-Fiber Sleeving

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Polyvinyl chloride or a copolymer of vinyl chloride on glass fiber
2. Temperature rating	Determined from thermal aging test
3. Voltage rating	300 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	4000 V minimum average, with no individual value below 2500 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 1600 V minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	Accelerated thermal aging; suggested temperatures 175, 160, 145, and 130 °C (347, 320, 293, and 266 °F) in accordance with UL 746B or CAN/CSA-C22.2 No. 0.17, using Grade A or Grade B vinyl-coated glass-fiber sleeving as a control material with an established relative thermal index
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens but not less than 2500 V
10. Cold bend test	No cracking of specimens cooled for 1 hour at –10.0 ±1.0 °C (+14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5
11. Horizontal-specimen flame test	See 5.7
12. VW-1 flame test (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{10} Ω·cm (minimum)
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 9
Requirements for 600 V Grade A Acrylic-Coated Glass-Fiber Sleeving Rated 155 °C (311 °F)

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Acrylic on glass fiber
2. Temperature rating	155°C (311°F)
3. Voltage rating	600 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	7000 V minimum average, with no individual value below 5000 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 2200 V

Table 9 Continued on Next Page

Table 9 Continued

Item	Information[a]
	minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	60 days at 190.0 ±1.0 °C (374.0 ±1.8 °F)
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens but not less than 3500 V
10. Cold bend test	No cracking of specimens cooled for 1 hours at –10.0 ±1.0 °C (14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5
11. Horizontal-specimen flame test	See 5.7
12. VW-1 (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{12} Ω·cm (minimum)
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 10
Requirements for 600 V Grade A Polymer-Coated Glass-Fiber Sleeving
Rated 180 °C (356 °F)

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Polymer on glass fiber
2. Temperature rating	180 °C (356 °F)
3. Voltage rating	600 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2)
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	7000 V minimum average, with no individual value below 5000 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 2200 V minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	Accelerated thermal aging; suggested temperatures 245, 230, 215 and 200 °C (473, 446, 419, and 392 °F) in accordance with UL 746B or CAN/CSA-C22.2 No. 0.17, using Grade A silicone glass-fiber sleeving as a control material with an established relative thermal index
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens but not less than 3500V
10. Cold bend test	No cracking of specimens cooled for 1 hour at –10.0 ±1.0 °C (14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5
11. Horizontal-specimen flame test	See 5.7
12. VW-1 flame test (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{10} Ω·cm (minimum)
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 11
Requirements for 300 V Grade B Acrylic-Coated Glass-Fiber Sleeving

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Acrylic on glass fiber
2. Temperature rating	Determined from thermal aging test
3. Voltage rating	300 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2)
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	4000 V minimum average, with no individual value below 2500 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 1600 V minimum average after being conditioned for 96 hours at 35.0 ±2.0 °C (95.0 ±3.6 °F) and 90 ±5 percent relative humidity
8. Aging (separate specimens) in a circulating-air oven	Accelerated thermal aging; suggested temperatures 200, 190, 180, and 170 °C (392, 374, 356, and 338 °F) in accordance with UL 746B or CAN/CSA-C22.2 No. 0.17, using Grade A or Grade B acrylic-coated glass-fiber sleeving as a control material with an established relative thermal index
9. Dielectric breakdown test	For specimens aged in accordance with Item 8, average breakdown voltage shall be at least half the breakdown voltage of unaged specimens but not less than 2500 V
10. Cold bend test	No cracking of specimens cooled for 1 hour at –10.0 ±1.0 °C (14.0 ±1.8 °F) and then wound for the number of turns indicated in Table 5 onto a cold mandrel of the diameter indicated in Table 5
11. Horizontal-specimen flame test	See 5.7
12. VW-1 flame test (optional)	See 5.8
13. Oil-resistance test (optional)	See 5.4
14. Volume resistivity	10^{12} Ω·cm (minimum)
15. Hydrolytic stability test	Not applicable

[a] *The information column is incomplete unless used in conjunction with the text.*

Table 12
Requirements for 600 V Grade A Silicone-Polymer-Coated Glass-Fiber Sleeving Rated 200 °C (392°F)

(See 5.6.1 and Table 1.)

Item	Information[a]
1. Material	Silicone polymer on glass fiber
2. Temperature rating	200 °C (392 °F)
3. Voltage rating	600 V
4. Sizes	24 AWG (0.559 mm) –1.0 in (25.4 mm) (See Table 2)
5. Inside diameter	See Table 2
6. Minimum overall wall thickness	See Table 2
7. Dielectric breakdown test	7000 V minimum average, with no individual value below 5000 V after being conditioned for 40 hours at 23.0 ±2.0 °C (73.4 ±3.6 °F) and 50 ±5 percent relative humidity; and a 2200 V

Table 12 Continued on Next Page