



UL 44

STANDARD FOR SAFETY

Thermoset-Insulated Wires and Cables

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UL Standard for Safety for Thermoset-Insulated Wires and Cables, UL 44

Nineteenth Edition, Dated January 9, 2018

Summary of Topics

This revision of ANSI/UL 44 dated May 14, 2021 includes a Modification of Requirements for Conductor Stranding Marking on Product; [6.1.5](#) and [Table 49](#)

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 new and revised requirements are substantially in accordance with Proposal(s) on this subject dated October 9, 2020.

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Sixth Edition



CSA Group
CSA C22.2 No. 38-18
Eleventh Edition



Underwriters Laboratories Inc.
UL 44
Nineteenth Edition

Thermoset-Insulated Wires and Cables

January 9, 2018

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ANSI/UL 44-2021



Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), 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 ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, 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. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

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This ANSI/UL Standard for Safety consists of the Nineteenth Edition including revisions through May 14, 2021. The most recent designation of ANSI/UL 44 as an American National Standard (ANSI) occurred on May 14, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

The Department of Defense (DoD) has adopted UL 44 on April 5, 1985. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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PREFACE

This is the harmonized ANCE, CSA Group, and UL standard for Thermoset-Insulated Wires and Cables. It is the Sixth edition of NMX-J-451-ANCE, the Eleventh edition of CSA C22.2 No. 38, and the Nineteenth edition of UL 44. This edition of NMX-J-451-ANCE supersedes the previous edition published in March 28, 2014. This edition of CSA C22.2 No. 38 supersedes the previous edition published in March 28, 2014. This edition of UL 44 supersedes the previous edition published in March 28, 2014. This harmonized standard has been jointly revised on May 14, 2021. For this purpose, CSA Group and UL are issuing revision pages dated May 14, 2021, and ANCE is issuing a new edition dated May 14, 2021.

This harmonized standard was prepared by the Association of Standardization and Certification, (ANCE), CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Electrical Wires and Cables, 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.

The present Mexican Standard was developed by the CT 20 Conductores from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the SC 20B Conductores para Baja Tensión.

This standard was reviewed by the CSA Integrated Committee on Fixed Installation Wires and Cables, 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.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

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 considered equivalent to, an IEC standard.

This standard provides requirements for insulated wires and cables for use in accordance with the electrical installation codes of Canada, Mexico, and the United States. At present there is no IEC standard for wires and cables for use in accordance with these codes. Therefore, this standard does not employ any IEC standard for base requirements.

This standard is published as an equivalent standard for ANCE, CSA Group 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.

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.

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Thermoset-Insulated Wires and Cables

1 Scope

1.1 This Standard specifies the requirements for single-conductor and multiple-conductor thermoset-insulated wires and cables rated 600 V, 1000 V, 2000 V, and 5000 V, for use in accordance with the rules of the Canadian Electrical Code, Part I, CSA C22.1, in Canada, Standard for Electrical Installations, NOM-001-SEDE, in Mexico, and the National Electrical Code (NEC), NFPA 70, in the United States of America.

See Annex [A](#) for the complete list of types and voltage ratings covered by this Standard and the specific electrical codes for which they are intended, and Annex [B](#) for a summary of construction and test requirements for these types.

1.2 [Table 1](#) provides a summary of the maximum conductor temperature, voltage ratings, and the number of insulated conductors for the types to which this Standard applies.

1.3 This Standard also specifies the requirements for submersible pump cables, with or without jackets, in Deep Well Submersible Water-Pump Cable, Section [7](#). No type-letter designations are assigned to these cables.

1.4 Products within this Standard might have applications not covered by the electrical codes listed in [1.1](#).

2 General

2.1 Units of measure

Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Reference publications

Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

Secretary of Energy

NOM-001-SEDE,
Standard for Electrical Installations

ANCE Standards

NMX-J-008-ANCE,
Tinned Soft or Annealed Copper Wire for Electrical Purposes – Specifications

NMX-J-012-ANCE,
Wires and Cables – Concentric Lay Stranded Copper Conductors for Electrical Purposes – Specifications

NMX-J-013-ANCE,
Wires and Cables – Rope Lay Stranded Copper Conductors Having Concentric Stranded Members for Electrical Purposes – Specifications

NMX-J-014-ANCE,
Wires and Cables – Rope Lay Stranded Copper Conductors Having Bunch Stranded Members for Electrical Purposes – Specifications

NMX-J-032-ANCE,
Wires and Cables – Concentric Lay Stranded Aluminum Cable for Electrical Purposes – Specifications

NMX-J-036-ANCE,
Soft or Annealed Copper Wire for Electrical Purposes – Specifications

NMX-J-040-ANCE,
Wires and Cables – Determination of the Moisture Absorption in Insulations of Electrical Conductors – Test Method

NMX-J-066-ANCE,
Determination of Diameters of Electrical Conductors – Test Method

NMX-J-093-ANCE,
Wires and Cables – Determination of the Resistance to Fire Propagation on Electrical Conductors – Test Method

NMX-J-177-ANCE,
Wires and Cables – Determination of Thickness in Semiconductive Shielding, Insulations, and Jackets of Electrical Conductors – Test Method

NMX-J-178-ANCE,
Wires and Cables – Ultimate Strength and Elongation of Insulation, Semiconducting Shields and Jackets of Electrical Conductors – Test Method

NMX-J-186-ANCE,
Wires and Cables – Accelerated Aging in Forced Convection Oven of Semiconducting Shields, Insulations and Jackets of Electrical Conductors – Test Method

NMX-J-190-ANCE,
Wires and Cables – Thermal Shock Resistance of PVC Insulations and Protective Coverings of Electrical Conductors – Test Method

NMX-J-191-ANCE,
Wires and Cables – Heat Distortion of Insulations and Protective Coverings of Electrical Conductors – Test Method

NMX-J-192-ANCE,
Electrical Products – Wires and Cables – Flame Test on Electrical Wires – Test Method

NMX-J-193-ANCE,
Wires and Cables – Cold Bend of Insulation and Non-Metallic Protective Jackets Used on Insulated Wire and Cable – Test Method

NMX-J-194-ANCE,
Wires and Cables – Oil Immersion Aging for Insulations and Jackets of Electrical Conductors – Test Method

NMX-J-212-ANCE,

Wires and Cables – Electrical Resistance, Resistivity and Conductivity – Test Method

NMX-J-293-ANCE,
Wires and Cables – Alternative Current and Direct Current Dielectric Voltage Withstand – Test Method

NMX-J-294-ANCE,
Wires and Cables – Insulation Resistance – Test Method

NMX-J-312-ANCE,
Wires and Cables – Tensile Strength and Elongation at Break of Electrical Conductors – Test Method

NMX-J-432-ANCE,
Wires and Cables – Determination of Hot Elongation and Permanent Deformation (Hot Creep), to Ethylene Propylene Rubber and Cross-Linked Polyethylene Insulations – Test Method

NMX-J-472-ANCE,
Electrical Products – Wires and Cables – Determination of the Amount of Halogen Acid Gas Evolved During the Controlled Combustion of Polymeric Materials Taken from Electrical Cables – Test Method

NMX-J-473-ANCE,
Wires and Cables – Spark Test – Test Method

NMX-J-474-ANCE,
Electrical Products – Wires and Cables – Determination of Specific Optical Density of Smoke Generated by Electrical Wires and Cables – Test Method

NMX-J-498-ANCE,
Wires and Cables – Vertical Tray Flame

NMX-J-532-ANCE,
Electrical Products – Wires and Cables – AA-8000 Series Aluminum Alloy Wires – Specifications

NMX-J-533-ANCE,
Wires and Cables – AA-8000 Series Aluminum Alloy Cables – Specifications

NMX-J-553-ANCE,
Wires and Cables – Weather Resistance of Insulation or Jacket of Electrical Conductors – Test Method

NMX-J-556-ANCE,
Wire and Cable Test Methods

CSA Group Standards

C22.1-15,
Canadian Electrical Code, Part I

CAN/CSA-C22.2 No. 0,
General Requirements – Canadian Electrical Code, Part II

C22.2 No. 96,
Portable Power Cables

C22.2 No. 245,

Marine Shipboard Cable

CAN/CSA C22.2 No. 2556,
Wire and Cable Test Methods

UL Standards

UL 1309
Marine Shipboard Cable

UL 2556
Wire and Cable Test Methods

UL 2806
Outline of Investigation for Heavy Duty Flexible Power Cable

ASTM (American Society for Testing and Materials)

B3-01(2013)
Standard Specification for Soft or Annealed Copper Wire

B8-11
Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B33-10
Standard Specification for Tinned-Coated Soft or Annealed Copper Wire for Electrical Purposes

B172-10
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B173-10
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

B298-07
Standard Specification for Silver-Coated Soft or Annealed Copper Wire

B355-11
Standard Specification for Nickel-Coated Soft or Annealed Copper Wire

B801-07(2012)
Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation

B835-04(2009)
Standard Specification for Compact Round Stranded Copper Conductors Using Single Input Wire Construction

B836-00(2011)
Standard Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction

B901-04(2011)

Standard Specification for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction

B902-13

Standard Specification for Compressed Round Stranded Copper Conductors, Hard, Medium-Hard, or Soft Using Single Input Wire Construction

D2663-08

Standard Test Methods for Carbon Black – Dispersion in Rubber

IEC (International Electrotechnical Commission)

IEC 60228 (2004-11)

Conductors of insulated cables

National Research Council Canada

National Building Code of Canada

NFPA (National Fire Protection Association)

NFPA 70-2014

National Electrical Code

2.3 General requirements

In Canada, general requirements applicable to this Standard are given in CAN/CSA-C22.2 No. 0.

3 Definitions

3.1 The following definitions apply in this Standard:

Composite insulation system – a multiple-layer system of materials that fulfills the requirements for both electrical and mechanical integrity of the cable or wire.

CP – a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

CPE – a thermoset compound whose characteristic constituent is chlorinated polyethylene.

EPCV – a thermoset compound whose characteristic constituent is a co-vulcanizate of ethylene and propylene with polyethylene.

EP – a thermoset compound whose characteristic constituent is a copolymer of ethylene and propylene, or a terpolymer of ethylene, propylene, and a small amount of nonconjugated diene, or a blend of both.

Equipment-grounding conductor – a conductor that is defined in the *National Electrical Code* and the *Standard for Electrical Installations* as "Grounding Conductor, Equipment", and defined in the *Canadian Electrical Code, Part I*, as "Bonding conductor".

NBR/PVC – a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Neoprene – a thermoset compound whose characteristic constituent is polychloroprene.

SBR/IIR/NR – designates a thermoset compound whose characteristic constituent is SBR (styrene and butadiene copolymer), IIR (butyl rubber), blends of SBR and IIR, or blends of SBR and/or IIR with NR (natural rubber).

Silicone (rubber) – a thermoset compound whose basic constituent is poly-organo-siloxane.

Thermoplastic – a jacket material that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the material, and that in the softened state can be shaped through the application of force.

Thermoset – an insulating or jacketing polymeric material which, when cross-linked, will not flow on subsequent heating. Cross-linking is accomplished either chemically or by irradiation.

XL – a thermoset compound whose characteristic constituent is cross-linked polyethylene, cross-linked polyvinyl chloride, cross-linked ethylene vinyl acetate, cross-linked ethylene ethyl acrylate, or blends thereof.

XL Filled– an XL material in which the mass fraction of materials other than the characteristic constituent polymer(s) is 10 percent or greater. These materials include carbon black, inorganic minerals, and solid flame retardants.

XL Unfilled – an XL material in which the mass fraction of materials other than the characteristic constituent polymer(s) is less than 10 percent. These materials include carbon black, inorganic minerals, and solid flame retardants.

4 Construction

4.1 Conductors

4.1.1 General

Circuit and equipment-grounding conductors shall be of copper, aluminum, or copper-clad aluminum.

4.1.2 Aluminum conductors

4.1.2.1 Aluminum conductors shall only be of aluminum conductor material (ACM), AA 8000 series alloy.

Annex C provides the chemical composition of recognized aluminum alloy conductor materials.

4.1.2.2 In Mexico, thermoset-insulated aluminum conductors are limited to sizes 13.3 mm² (6 AWG) and larger in accordance with NOM-001-SEDE, *Standard for Electrical Installations*.

4.1.3 Copper-clad aluminum conductors

In the United States, the requirements of Annex D shall apply to solid conductors or the individual wires of stranded conductors prior to stranding.

In Canada and Mexico, copper-clad aluminum conductors shall not be used in thermoset-insulated wires and cables.

4.1.4 Copper conductors

4.1.4.1 General

The requirements of [4.1.4.2](#) or [4.1.4.3](#) shall apply to solid conductors or the individual wires of stranded conductors prior to stranding. If the insulation adjacent to a copper conductor is of a material that corrodes unprotected copper, as determined by the requirement in [5.7](#), or if a protective separator in compliance with [4.1.8](#) is not provided, the solid conductor and each of the individual strands of a stranded conductor shall be separately covered with a coating as described in [4.1.4.2](#).

4.1.4.2 Coated copper conductors

4.1.4.2.1 Each tin-coated conductor shall comply with the requirements of ASTM B33 or NMX-J-008-ANCE; a nickel-coated wire shall comply with ASTM B355, and a silver-coated wire shall comply with ASTM B298. Conductors coated with other metals or alloys shall be subjected to special investigation.

Note: In Mexico, the use of ASTM B355 is recommended for nickel-coated wire, and the use of ASTM B298 is recommended for silver-coated wire.

4.1.4.2.2 A metal coating, when not required, is appropriate for use on solid or individual wires (strands) or selected wires, such as the outer layer of wires of a stranded conductor. The metal coating when used shall comply with [4.1.4.1](#).

4.1.4.3 Uncoated copper conductors

Each wire in an uncoated copper conductor shall comply with the requirements of ASTM B3 or NMX-J-036-ANCE.

4.1.5 Sizes and stranding

4.1.5.1 Sizes

4.1.5.1.1 Conductors shall be of a size and assembly indicated for the finished wire type in [Table 2](#).

4.1.5.1.2 Copper strands smaller than 0.0127 mm² (36 AWG) and aluminum strands smaller than 0.25 mm² (24 AWG) shall not be used. A compact stranded conductor shall not be segmented. Aluminum conductors produced with greater strand counts than Class D shall have the same strand size and strand count as the equivalent stranded copper conductors.

Note 1: Conductor sizes specified in IEC publications are not recognized in the CE Code, Part I, NEC, or NOM-001-SEDE; however, these can be required for wires and cables intended for use outside of the codes. Information on these metric conductors is given in Annex [E](#).

Note 2: Conductor sizes for rope lay stranded flexible conductors specified for transportation, ships, rail and the like are not recognized for these applications in the CE Code, Part I, NEC, or NOM-001-SEDE. Information on these conductors is given in Annex [E](#).

4.1.5.2 Stranding

The number of strands in the conductors shall be in accordance with [Table 3](#).

4.1.5.3 Concentric

Concentric conductors shall be a round conductor consisting of a round central core surrounded by one or more layers of helically laid round wires all having the same diameter.

4.1.5.4 Compact

A compact-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more helically laid wires, and formed into a smooth outermost layer by rolling, drawing, or other means. The lay length of every layer shall not be less than 8 times nor more than 16 times the outside diameter of the completed conductor except that, for sizes 33.6 mm² (2 AWG) and smaller, the maximum lay length shall be 17.5 times the outside diameter. The direction of lay of the outermost layer shall be left-hand, and it shall be reversed or unidirectional/unilay in successive layers.

4.1.5.5 Compressed

A compressed-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more layers of helically laid wires with either the direction of lay reversed in successive layers or unilay or unidirectional lay. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers shall be slightly compressed by rolling, drawing, or other means to change the originally round strands to various shapes that achieve filling of some of the spaces originally present between the strands.

4.1.5.6 Assembly of strands

A 19-wire combination round-wire unilay stranded conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire, and an outer layer consisting of six wires with the same diameter as the central wire, alternated with six wires with a diameter of 0.732 times the diameter of the central wire. No particular assembly of the individual wires of any other stranded conductor is required. However, simple bunching (untwisted strands) shall not be used. The length of lay of the strands in a bunch-stranded conductor twisted as a single bunch shall not be greater than indicated in [Table 4](#). The direction of lay of the strands in a bunch-stranded conductor shall be left-hand.

4.1.5.7 Length and direction of lay

Every stranded conductor other than a compact-stranded conductor, or a bunch-stranded conductor twisted as a single bunch, shall comply with the following:

- a) The direction of lay of the strands, members, or ropes in a 13.3 – 1010 mm² (6 AWG – 2000 kcmil) conductor other than a compressed unilay single input wire, combination unilay, or a compressed unilay or compressed unidirectional lay conductor shall be reversed in successive layers. Rope-lay conductors with bunch-stranded or concentric-stranded members shall be either unidirectional or reversed. All unidirectional lays and the outer layer of reversed lays shall be in the left-hand direction.
- b) For a bunch-stranded member of a rope-lay-stranded conductor in which the members are formed into rope-stranded components that are then cabled into the final conductor, the length of lay of the individual members within each component shall not be more than 30 times the outside diameter of one of those members.
- c) For a concentric-stranded member of a rope-lay-stranded conductor, the length of lay of the individual strands in a member shall be 8 – 16 times the outside diameter of the member. The direction of lay of the strands in each member shall be reversed in successive layers of the member.

- d) The length of lay of the strands in both layers of a 19-wire combination round-wire unilay-stranded copper or aluminum conductor shall be 8 – 16 times the outside diameter of the completed conductor. Otherwise, the length of lay of the strands in every layer of a concentric-lay-stranded conductor consisting of fewer than 37 strands shall be 8 – 16 times the outside diameter of the conductor.
- e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of the conductor.
- f) The length of lay of the members or ropes in the outer layer of a rope-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer.

The length of lay shall be determined in accordance with the test, Length of Lay, in UL 2556, CSA C22.2 No. 2556, or NMX-516-ANCE.

4.1.6 Diameter and cross-sectional area

4.1.6.1 The nominal diameters of solid and stranded conductors are shown in [Table 5](#) – [Table 10](#). There are no diameter requirements for conductor classes not referenced in [Table 5](#) – [Table 10](#). See [5.2](#) for conductor resistance requirements. The minimum diameter for a stranded conductor is 98 percent of the nominal. The maximum diameter of any conductor is 101 percent of the nominal. Verification of the diameter shall be determined in accordance with the test, Conductor diameter, in UL 2556, CSA C22.2 No. 2556, or NMX-J-066-ANCE.

4.1.6.2 Conductor sizes in mm² (AWG/kcmil) covered by this Standard are shown in [Table 5](#). The nominal cross-sectional area of a conductor identified in [Table 5](#) is not a requirement.

4.1.7 Joints

4.1.7.1 A joint (butt splice) where allowed shall be made before or after insulating and prior to further processing. Where joints (butt splices) are made after insulating, the insulation applied over the joint shall be of the same insulation material used throughout the length of the conductor, or of another insulating material that meets or exceeds the electrical, physical, and mechanical requirements of this Standard for the original insulating material.

4.1.7.2 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall neither increase the diameter nor materially decrease the strength of the conductor or the individual wire. Not more than one of the wires in a stranded conductor of 19 wires or less, nor more than one of the wires in any given layer in a stranded conductor of more than 19 wires, shall be joined in any 0.3 m (1 ft) of conductor.

4.1.7.3 In a rope-lay-stranded conductor, which consists of a central core surrounded by one or more layers of stranded members (primary groups), each member shall be considered equivalent to a solid wire, and as such, shall be spliced as a unit. These joints shall not be any closer together than two lay lengths.

4.1.7.4 A joint shall be allowed in a Class B stranded 2.08 mm² (14 AWG), 3.31 mm² (12 AWG), 5.26 mm² (10 AWG), or 8.37 mm² (8 AWG) insulated copper conductor intended to be used in a multiple-conductor cable, with an overall covering. The joint (butt splice) shall be made by machine brazing or welding the entire conductor such that the resulting solid section of the stranded conductor is no longer than 13 mm (0.50 in). In addition, the joint shall not increase the diameter of the conductor, there shall be no sharp points, and the distance between joints in a single conductor shall not average less than 1000 m (3280 ft) in any finished length of that single insulated conductor. Insulated conductors with a joint (butt splice) shall not be surface marked with a type designation.

4.1.8 Separator

A separator of suitable material, when present between the conductor and the insulation, shall be of contrasting color to the conductor color, except that clear or green shall not be used. A white colored separator over aluminum complies with this requirement. The separator and the other wire or cable components shall not have any deleterious effect on one another.

4.2 Insulation

4.2.1 General

4.2.1.1 Conductors shall be insulated with one of the thermoset materials shown in [4.2.1.3](#) and [Table 20](#). The insulation shall comply with all the requirements of this Standard. The insulation shall be applied directly over the conductor or over the separator, if provided, and shall fit tightly thereto. The insulation shall be free from pores, splinters, and other inhomogeneities visible with normal or corrected vision without magnification.

4.2.1.2 The physical properties of the insulation shall comply with [Table 11](#), when determined in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556, CSA C22.2 No. 2556, or NMX-J-178-ANCE and NMX-J-186-ANCE.

4.2.1.3 The following insulation materials are identified for use in this Standard:

- a) XL;
- b) EPCV;
- c) Composite insulation:
 - i) Inner – EP, EPCV, silicone, or XL;
 - ii) Outer – EPCV, XL, CP, or CPE;
- d) EP;
- e) SBR/IIR/NR;
- f) Silicone; and
- g) CP, CPE.

See [4.10](#) for performance requirements for insulation materials other than those identified for use in items (a) – (g).

4.2.2 Repairs

Where a repair is made in the insulation, the insulation applied to the repaired section shall be equivalent to that removed, and the repaired section of the finished conductor shall comply with the same electrical and thickness requirements specified in this Standard.

In Mexico, repairs to finished conductors are not permitted.

4.2.3 Thickness

The minimum average thickness and minimum insulation thickness at any point shall be as shown in [Table 12](#) – [Table 19](#), when measured in accordance with the test, Thickness, as described in UL 2556, CSA C22.2 No. 2556, or NMX-J-177-ANCE.

4.2.4 Centering

The insulated conductor shall have a circular cross-section, with the insulation applied concentrically about the conductor or any separator (making the conductor plus any separator well centered in the insulation), fitting tightly on the conductor or over any separator. If the insulation is applied in more than one layer, adjacent layers shall be vulcanized, cured, or cross-linked into an integral mass, with the layers not separable. This mass shall be taken as a whole for all measurements and tests, with the exception that the thicknesses of the layers of composite insulation shall be measured separately.

4.2.5 Insulation strand penetration (fall-in)

The insulation shall not penetrate the stranded conductor in a manner that would hamper the free stripping of the insulation when tested in accordance with the test, Fall-in of extruded materials, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

4.3 Jackets or fibrous coverings over single conductors

4.3.1 A single-conductor wire and each conductor of any 2-conductor flat parallel cable, and each conductor of any multiple-conductor cable, shall have a protective covering of fibrous material or a jacket applied over the outer surface of the insulation, in accordance with [Table 20](#). The temperature rating of the jacket shall be the same as that of the insulated conductor. Requirements for protective coverings other than jackets are covered in Annex [G](#) of this Standard. Physical property requirements for jackets shall comply with [Table 21](#), when tested in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556, CSA C22.2 No. 2556, or NMX-J-178-ANCE and NMX-J-186-ANCE. Jacket thickness requirements are shown in [Table 22](#) – [Table 24](#).

4.3.2 The following materials are identified for use as jackets or coverings:

- a) Rubber-filled woven cotton tape;
- b) Polypropylene tape under a fibrous wrap or braid;
- c) Oriented polyethylene terephthalate tape under a fibrous wrap or braid;
- d) Fibrous braid;
- e) Fibrous wrap;
- f) Neoprene jacket;
- g) NBR/PVC jacket;
- h) CPE jacket;
- i) CP jacket;
- j) PVC jacket; and
- k) XL jacket.

See [4.10](#) for the performance requirements of jacket materials other than those identified for use in items (a) – (k).

4.4 Shielding (optional)

Shielding applied over a single conductor(s) or over an assembly of conductors shall consist of a braid, a helically applied flat copper tape, a longitudinally corrugated copper tape, or any combination thereof. For helically applied tapes, the overlap shall be a minimum of 12.5 percent or 6.35 mm (0.25 in), whichever is greater. For longitudinally applied tapes, the minimum overlap shall be 12.5 percent of the width of the tape. Shielded single-conductor cables, not intended for use in multiple-conductor cables, shall be jacketed in accordance with [4.3](#). Shielded multiple-conductor assemblies shall be jacketed in accordance with [4.9](#).

4.5 Multiple-conductor cables

4.5.1 Lay of cabled conductors

4.5.1.1 The two or more conductors in a multiple-conductor round cable or assembly other than the assemblies covered in [4.11](#) shall be cabled in accordance with [4.5.1.2](#) and [4.5.1.3](#).

4.5.1.2 The component wires or cables of a 2-conductor cable shall be assembled as follows:

- a) All cables in sizes larger than 13.3 mm² (6 AWG) twisted in accordance with [4.5.1.3](#); and
- b) All cables in sizes 13.3 mm² (6 AWG) and smaller twisted in accordance with [4.5.1.3](#) or parallel.

4.5.1.3 A multiple-conductor cable, other than 2-conductor parallel cable, shall have the finished insulated conductors cabled together with a length of lay not greater than indicated in [Table 25](#). The direction of lay may be changed at intervals throughout the length of the cable. The intervals need not be uniform. In a cable in which the direction of lay is changed:

- a) Each area in which the lay is right- or left-hand for a minimum of five complete twists (full 360 degree cycles) shall have the insulated conductors cabled with a length of lay that is not greater than indicated in [Table 25](#); and
- b) The length of each lay-transition zone (oscillated section) between these areas of right- and left-hand lay shall not exceed 1.8 times the maximum length of lay indicated in [Table 25](#).

4.5.1.4 The overall diameter of the assembly, where required, shall be calculated as outlined in [4.9.3](#).

4.5.1.5 If the assembly consists of a number of layers of insulated conductors, the direction of lay of the outer layer shall be either left-hand or right-hand and the direction of lay of the inner layers shall be reversed. The length of lay shall be determined in accordance with the test, Length of lay, in UL 2556, CSA C22.2 No. 2556, or NMX-J-516-ANCE.

4.5.2 Equipment-grounding conductor

4.5.2.1 Equipment-grounding conductors, whether bare or insulated, shall not be smaller than the sizes shown in [Table 26](#). Where multiple equipment-grounding conductors are employed, they shall have a combined area not less than the sizes given in [Table 26](#). In cables containing more than one size of circuit conductor, the minimum equipment-grounding conductor size shall be determined by the size of the largest circuit conductor.

4.5.2.2 The equipment-grounding conductor shall be of the same flexible stranding class as that of the accompanying circuit conductors or of more flexible stranding.

4.6 Color coding

4.6.1 Color of insulated equipment-grounding conductor

4.6.1.1 An insulated conductor intended for use as an equipment-grounding conductor shall be finished to show the color green throughout the entire length and circumference of its outer surface, with or without one or more straight or helical, broken (non-continuous) or unbroken yellow stripes. See [4.6.1.3](#) for details on stripes.

In the United States and Mexico, the requirements of [4.6.1.1](#) apply to 13.3 mm² (6 AWG) or smaller.

In Canada, the requirements of [4.6.1.1](#) apply to 33.6 mm² (2 AWG) or smaller.

4.6.1.2 Regardless of conductor size, if the manufacturer elects to color larger conductor sizes, the requirements of [4.6.1.1](#) and [4.6.1.3](#) shall apply.

4.6.1.3 Stripes as specified in [4.6.1](#), [4.6.2](#), and [4.6.3](#) shall be of even or varying width and shall occupy a total of 5 – 70 percent of the calculated circumference of the outer surface of the finished insulated conductor, with no individual width less than 5 percent of that same circumference. The width shall be measured perpendicular to each stripe. Where broken stripes are appropriate, they shall consist of a series of identical marks and spaces, the length of each mark shall be at least 3 mm (1/8 in), and the linear spacing between marks shall not be greater than 19 mm (3/4 in).

4.6.2 Identification of ungrounded circuit conductor(s)

4.6.2.1 Each ungrounded circuit conductor shall be finished to show a color or combination of colors other than and in contrast with white, gray, and green. The outer surface so colored also complies with the intent of this requirement where it contains any one of the following added throughout the entire length of the cable in a color or combination of colors other than and in contrast with white, gray, and green:

- a) One or more broken or unbroken straight or helical stripes. See [4.6.1.3](#) for details on stripes;
- b) An unbroken series of identical hash marks or other symbols with dimensions as specified for stripes and with regular spacing; and
- c) Numerals, letters, words, or a combination thereof that comply with this Standard.

4.6.2.2 In Canada, the color or combination of colors of the ungrounded and grounded circuit conductor (s) in a multiple-conductor cable shall also be in accordance with Annex [H](#).

In Mexico and the United States, the requirements in Annex [H](#) do not apply.

4.6.2.3 The markings covered in [4.6.2](#) and [4.6.3](#) shall not conflict with and shall be readily distinguishable from any of the other required or optional markings covered in this Standard.

4.6.3 Identification of grounded circuit conductor(s)

An insulated conductor intended for use as a grounded circuit conductor shall be finished to show the color white or gray throughout the entire length and circumference of its outer surface, or shall be identified by three continuous straight or helical, unbroken white stripes on other than green insulation, along its entire length. Straight stripes shall be placed a nominal 120 degrees apart. Where multiple grounded circuit

conductors are used in a cable, no more than one shall employ white stripes. Additional conductors intended to be grounded circuit conductors shall be finished white (gray is not appropriate except in a 4-circuit-conductor cable) and shall have any one of the features described in [4.6.2.1](#) (a), (b), or (c) throughout the length of the wire or cable in a color or combination of colors other than, and in contrast with, white, gray, or green.

See [4.6.1.3](#) for details on stripes.

4.7 Fillers and protective materials

When used in a cable or assembly, fillers or any additional optional protective materials shall not have any deleterious effect on other cable components.

4.8 Jacket separators

4.8.1 Where a thermoplastic jacket is used over insulation other than XL, a polymeric tape not less than 0.02 mm (0.8 mil) thick shall be incorporated under the jacket. The use of polymeric tape over XL insulation shall be optional. Where a thermoset jacket is used, a suitable separator applied between the insulation and the jacket shall be optional. The separator and other wire or cable components shall not have any deleterious effect on one another.

4.8.2 The tape shall be applied either helically or longitudinally to completely cover the underlying components and so that it has an overlap of not less than 25 percent of its width or 6.3 mm (0.25 in), whichever is less.

4.9 Jackets

4.9.1 General

4.9.1.1 A multiple-conductor cable shall have a protective covering of fibrous material or a jacket applied over the cabled conductors in accordance with [Table 20](#). Requirements for protective coverings, other than jackets, applied over cabled conductors are provided in Annex G of this Standard. Where a thermoplastic or thermoset jacket is required or applied, the jacket shall fit tightly and be applied over cabled conductors or over a jacket separator in compliance with [4.8](#). The temperature rating of the jacket shall be 75°C. The use of a 90°C rated jacket is optional. The physical properties of the jacket shall comply with [Table 21](#), when determined in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556, CSA C22.2 No. 2556, or NMX-J-178-ANCE and NMX-J-186-ANCE. Requirements for jackets over individual conductors are described in [4.3](#).

4.9.1.2 Materials identified for use as jackets are described in [4.3.2](#). See [4.10](#) for performance requirements for jacket materials other than those identified in [4.3.2](#).

4.9.2 Jacket thickness

The minimum average and minimum thickness of a jacket shall not be less than indicated in [Table 27](#) when determined by the method described in the test, Thickness, in UL 2556, CSA C22.2 No. 2556, or NMX-J-177-ANCE.

4.9.3 Diameter of conductor assembly under jacket

To calculate the diameter under the jacket, use the nominal and, where specified, the minimum average dimensions of the components in the assembly.

4.10 Evaluation of new materials – Establishment of dry temperature rating of alternative insulation and jacketing materials for use in this Standard

4.10.1 Materials having characteristics different from those specified in [Table 11](#) or [Table 21](#) shall be evaluated for the requested temperature rating in accordance with [5.22](#). To be evaluated, insulations for use without jackets or additional coverings, the outer insulation layer of a composite insulation, and jackets shall have an initial absolute minimum tensile strength of not less than 6.8 MPa (1000 lbf/in²), and an absolute minimum elongation of 100 percent before aging. Insulations for use with jackets or additional coverings, or the inner layer of composite insulation, shall have an initial absolute minimum tensile strength of not less than 3.4 MPa (500 lbf/in²) and an absolute minimum elongation of 100 percent before aging.

4.10.2 The temperature rating and thickness of insulation and/or a jacket of materials having characteristics different from those specified in [Table 11](#) or [Table 21](#) shall be as required for the specific thermoset-insulated wire or cable type. The electrical, mechanical, and physical characteristics of the wire or cable using these materials shall comply with all the requirements for an insulation or jacket material named in [4.2.1.3](#) or [4.3.2](#) for the required temperature rating.

4.11 Assemblies that include single-conductor thermoset-insulated wires

4.11.1 When cabled into assemblies (length and direction of lay not specified), single-conductor wires that comply with the requirements in this Standard shall not be considered as cables and shall not include overall coverings. An open, helically applied binder or wrap, intended only to hold the assembly together, shall be optional.

4.11.2 Completed assemblies shall comply with the requirements of [4.11.3](#).

4.11.3 Completed assemblies shall comply with the following requirements:

- a) Assemblies in which an uninsulated conductor is included shall be tested for dielectric voltage-withstand in accordance with [5.24](#), except that immersion in water shall be for at least 1 h.
- b) Each assembly in which an uninsulated conductor is not included shall be tested in accordance with [5.24](#) (1 h or longer immersion), or be spark tested as indicated in [5.23](#) with each layer in a multiple-layer assembly spark tested separately.
- c) Each 2.08 – 8.37 mm² (14 – 8 AWG) conductor in an assembly shall be individually tested for continuity in accordance with [5.26](#) after the assembly is completed.

5 Test Requirements

5.1 General

Every length of finished insulated conductor shall be capable of complying with the requirements of [5.2](#) – [5.26](#), as applicable.

5.2 Conductor resistance

5.2.1 The direct-current resistance of the conductor shall not be greater than as specified in [Table 28](#) – [Table 33](#) inclusive. For conductors for which the maximum resistance is not tabulated in [Table 28](#) – [Table 33](#), the maximum resistance for a given size of the solid or stranded construction shall be determined by multiplying the maximum resistance tabulated in the tables for uncoated copper of the same size and construction by the ratio of 100 percent IACS (International Annealed copper Standard) to the percent conductivity as shown in the applicable conductor standard.

5.2.2 The DC resistance when measured on a single conductor within a completed twisted conductor assembly or multiple-conductor cable shall not exceed the value tabulated in [Table 28](#) – [Table 33](#) as applicable, for a single conductor multiplied by whichever of the following factors is applicable:

- a) Cabled in one layer: 1.02;
- b) Cabled in more than one layer: 1.03; or
- c) Cabled as an assembly of other pre-cabled units: 1.04

5.2.3 Compliance shall be determined in accordance with the test, DC Resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-212-ANCE.

5.3 Tests on aluminum conductors

5.3.1 Physical properties

5.3.1.1 All aluminum conductors shall have a minimum elongation of 10 percent. Wires (strands) removed from a finished stranded conductor shall have a tensile strength of 98 – 159 MPa (14,250 – 23,100 lbf/in²). The tensile strength of solid conductors shall be 103 – 152 MPa (15,000 – 22,000 lbf/in²). Compliance shall be determined in accordance with the test, Physical properties of conductors – Maximum tensile strength and elongation at break, in UL 2556, CSA C22.2 No. 2556, or NMX-J-312-ANCE.

5.3.1.2 Compliance with the requirements in [5.3.1.1](#) for stranded conductors shall be determined either on wires taken prior to stranding into conductors, any strand(s) taken from a stranded conductor, or the stranded conductor as a whole, at the option of the manufacturer. In case of non-compliance, the results from specimens taken from a center strand only shall be considered for referee purposes.

5.3.2 High-current heat cycling [3.31 – 8.37 mm² (12 – 8 AWG) conductors only]

5.3.2.1 A minimum of 24 thermocouples (26 thermocouples if one test jig is rejected before 51 cycles are completed) shall measure less than 175°C, with each temperature profile exhibiting thermal stability.

5.3.2.2 Compliance shall be determined in accordance with the test, High-current heat cycling for aluminum conductors, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.4 Long-term insulation resistance in water

5.4.1 Acceptance criteria

5.4.1.1 The insulation, without the protective covering, of wet-rated single-conductor cable and of the individual single conductors of multiple-conductor cable shall have an insulation resistance at the rated temperature in tap water that is not less than as specified in [Table 34](#) – [Table 36](#) at any time while immersed. The period of immersion shall be 12 weeks or more if the insulation resistance throughout the last 6 weeks of the initial 12-week immersion period is greater than 3 GΩ·m (10 MΩ·1000 ft). The period of immersion shall be at least 24 weeks and no more than 36 weeks, unless requested by the manufacturer, if the insulation resistance is less than 3 GΩ·m (10 MΩ·1000 ft) throughout the last 6 weeks of the initial 12-week immersion period, but equals or exceeds the value specified in [Table 34](#) – [Table 36](#). An AC voltage equal to the voltage rating of the wire (600 V, 1000 V, or 2000 V rms) shall be applied to the insulated conductor at all times other than while measuring the insulation resistance. These tests are accelerated tests. Composite insulation systems shall be tested as a unit. The values in [Table 34](#) – [Table 36](#) apply only to conductor types with the corresponding insulation thicknesses specified in this Standard. For other parameters of any material, the insulation resistance values shall be calculated by means of the formula in Annex I.

5.4.1.2 The maximum weekly decrease in insulation resistance as determined in 5.4.1.3 shall not be more than 4 percent if the insulation resistance throughout the last 6 weeks of the immersion period is $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$) or more; and shall not be more than 2 percent if the insulation resistance throughout the last 6 weeks of the immersion period is less than $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$), but more than the values specified in Table 34 – Table 36. If the results of the test do not meet either of these criteria, but are more than the values specified in Table 34 – Table 36, the period of immersion may be extended by one-week intervals at the request of the manufacturer, subject to the minimum test period established in 5.4.1.1. If the insulation resistance falls below the values specified in Table 34 – Table 36, the test shall be discontinued and considered a failure.

5.4.1.3 The maximum weekly decrease in insulation resistance shall be calculated as the slope of a least squares best fit straight line curve drawn through a three-week moving average of the last six weeks of raw test data. Each three-week moving average data point for the least squares best fit straight line curve shall be calculated as the average of the raw data for the current week and the previous two weeks (for example, the week 12 data point would be the average of the weeks 10, 11, and 12 raw data values).

5.4.1.4 Compliance with 5.4.1.1 – 5.4.1.3 shall be determined in accordance with the test, Long-term insulation resistance (Method 1), in UL 2556, CSA C22.2 No. 2556, or NMX-J-294-ANCE.

5.5 Long-term insulation resistance in air for 90°C rated conductors

5.5.1 General

This test is not required on insulated conductors that comply with the requirements of 5.4.

5.5.2 Acceptance criteria

5.5.2.1 The insulation on Type XHH, RHH, and R90 wires shall have an insulation resistance in air at $97 \pm 1^\circ\text{C}$ that is not less than as specified in Table 37 – Table 38, at any time during an extended period in an acceptable full-draft circulating-air oven. The period in the oven shall be 12 weeks or more if the insulation resistance throughout the last 6 weeks of the initial 12-week period in the oven is greater than $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$). The period in the oven shall be at least 24 weeks and no more than 36 weeks, unless requested by the manufacturer, if the insulation resistance is less than $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$) at any point during the last 6 weeks of the initial 12-week period in the oven, but equals or exceeds the value specified in Table 37 – Table 38. An AC voltage equal to the voltage rating of the wire (600 V, 1000 V, or 2000 V rms) shall be applied to the insulated conductor at all times other than while measuring the insulation resistance. These tests are accelerated tests. Composite insulation systems shall be tested as a unit. The values in Table 37 – Table 38 apply only to conductor types with the corresponding insulation thicknesses specified in this Standard. For other parameters of any material, the insulation resistance values shall be calculated by means of the formula in Annex I.

5.5.2.2 The insulation resistance shall be measured between the conductor and an electrode consisting of graphite powder, a snug-fitting copper braid of minimum 90 percent coverage applied over the insulation, or an equivalent means.

5.5.2.3 The maximum weekly decrease in insulation resistance as determined in 5.5.2.4 shall not be more than 4 percent if the insulation resistance throughout the last 6 weeks of the period in the oven is $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$) or more; and shall not be more than 2 percent if the insulation resistance at any point during the last 6 weeks of the initial 12-week period in the oven is less than $3 \text{ G}\Omega\cdot\text{m}$ ($10 \text{ M}\Omega\cdot 1000 \text{ ft}$), but more than the values specified in Table 37 – Table 38. If the results of the test do not meet either of these criteria, but are more than the values specified in Table 37 – Table 38, the period of immersion may be extended by one-week intervals at the request of the manufacturer, subject to the minimum test period established in 5.4.1.1. If the insulation resistance falls below the values specified in Table 37 – Table 38, the test shall be discontinued and considered a failure.

5.5.2.4 The maximum weekly decrease in insulation resistance shall be calculated as the slope of a least squares best fit straight line curve drawn through a three-week moving average of the last six weeks of raw test data. Each three-week moving average data point for the least squares best fit straight line curve shall be calculated as the average of the raw data for the current week and the previous two weeks (for example, the week 12 data point would be the average of the weeks 10, 11, and 12 raw data values).

5.5.2.5 Compliance with [5.5.2.1](#) – [5.5.2.4](#) shall be determined in accordance with the test, Long-term insulation resistance (Method 2), in UL 2556, CSA C22.2 No. 2556, or NMX-J-294-ANCE.

5.6 Capacitance and relative permittivity

5.6.1 The insulation, without the protective covering, of wet-rated single-conductor cable and of the individual single conductors of multiple-conductor cable immersed in water at rated temperature, $75 \pm 1^\circ\text{C}$ or $90 \pm 1^\circ\text{C}$, shall comply with each of the following:

- a) The relative permittivity determined after immersion for 24 h shall not be more than 10.0 for CP, silicone, and CPE insulation and shall be 6.0 or less for all other insulations.
- b) The capacitance for CP, silicone, and CPE insulations after immersion for 14 d shall be no more than 6 percent higher than the capacitance after 24 h immersion, and no more than 10 percent higher for all other insulations.
- c) The capacitance determined for CP, silicone, and CPE insulations after 14 d immersion shall be no more than 2 percent higher than the capacitance determined after immersion for 7 d, and no more than 4 percent higher for all other insulations.

5.6.2 Composite insulation systems shall be tested as a unit and shall comply with the "other insulations" criteria in (a), (b), and (c) of [5.6.1](#). Compliance shall be determined in accordance with the test, Capacitance and relative permittivity, in UL 2556, CSA C22.2 No. 2556, or NMX-J-040-ANCE.

5.7 Conductor corrosion

Bare unprotected copper conductor used without a separator under the insulation or jacket shall not show surface deterioration during visual examination. Compliance shall be determined in accordance with the test, Copper corrosion, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE, when performed at the temperature and for the duration specified in [Table 11](#), after air oven accelerated aging.

5.8 Insulation fall-in

The stranded conductor shall be free of residual insulation or extruded conductor-shield material. Compliance shall be determined in accordance with the test, Fall-in of extruded materials, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.9 Heat shock of thermoplastic jacket

A thermoplastic jacket shall not show any cracks after a specimen of finished wire or cable has been wound or bent around a mandrel having a diameter in accordance with [Table 39](#), and while still on the mandrel, subjected to a temperature of $121 \pm 1^\circ\text{C}$ for a period of 1 h. For flat cable, the minor cross-sectional dimension of the cable shall be used in determining the mandrel diameter, and the cable shall be wound or bent flatwise around the mandrel. Compliance shall be determined in accordance with the test, Heat shock, in UL 2556, CSA C22.2 No. 2556, or NMX-J-190-ANCE.

5.10 Flexibility of separator under a thermoplastic jacket

5.10.1 A separator under a thermoplastic jacket, as required in [4.8.1](#), shall not show cracks or open up after a specimen of the finished single-conductor wire or cable, or of the finished multiple-conductor cable, is wound at room temperature around a mandrel. Compliance shall be determined in accordance with the test, Flexibility of separator tape under a jacket, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.10.2 Compliance with [5.10.1](#) shall be determined using a mandrel having a diameter 2.5 times the diameter of the wire or cable under test, except for 2-conductor parallel constructions, where the mandrel diameter shall be 2.5 times the minor dimension of the cable. Specimens having a diameter or minor dimension of 19 mm (0.75 in) or less shall be wound for three turns around the mandrel. Specimens having a diameter or minor dimension greater than 19 mm (0.75 in) shall be bent 180 degrees around the mandrel. The winding shall be done at a uniform rate so that the time taken for winding three turns does not exceed 1 min.

5.10.3 The condition of the separator shall be determined by opening the jacket sufficiently to view the overlap of the tape separator, and examining the tape while the wire or cable is still around the mandrel.

5.11 Cold bend and cold impact

5.11.1 Cold bend

After conditioning at a temperature of minus $25 \pm 1^\circ\text{C}$ for 4 h, the insulation or jacket of a wire, cable, or assembly shall not show any cracks, nor shall any thread or threads of a fibrous covering of a wire, cable, or assembly show any breaks. Compliance shall be determined in accordance with the test, Cold bend, in UL 2556, CSA C22.2 No. 2556, or NMX-J-193-ANCE. The mandrel diameter shall be as specified in [Table 40](#) for single conductors. Single-conductor specimens $2.08 - 33.6 \text{ mm}^2$ (14 – 2 AWG) shall be wound for six adjacent turns around the mandrel. Specimens 42.4 mm^2 (1 AWG) and larger shall be bent 180 degrees around the mandrel. The mandrel diameter shall be as specified in [Table 41](#) for 2-conductor parallel and multiple-conductor cables. When the wire or cable is marked with the optional -40C marking in accordance with [6.1.9](#), conditioning shall be carried out at a temperature of minus $40 \pm 1^\circ\text{C}$.

5.11.2 Cold impact (optional)

Where required, the jacket and/or insulation on at least 8 out of 10 completed cable specimens shall not crack or rupture, nor shall any thread or threads of a fibrous covering, if present, break, when tested at minus 40°C . Compliance shall be determined in accordance with the test, Cold impact, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.12 Deformation

5.12.1 The thickness of XL insulation shall not decrease more than 30 percent for conductor sizes $2.08 - 107.2 \text{ mm}^2$ (14 – 4/0 AWG) or 15 percent for conductor sizes $127 - 1010 \text{ mm}^2$ (250 – 2000 kcmil) when subjected for 30 min, at a temperature of $131^\circ\text{C} \pm 1^\circ\text{C}$, to the load specified in [Table 42](#). Compliance shall be determined in accordance with the test, Deformation, in UL 2556, CSA C22.2 No. 2556, or NMX-J-191-ANCE, except that the test specimens shall not be pre-conditioned.

5.12.2 The thickness of a jacket of thermoplastic material shall not decrease more than 50 percent when subjected to a temperature of $121 \pm 1^\circ\text{C}$ while under a load of 2000 g. Compliance shall be determined in accordance with the test, Deformation, in UL 2556, CSA C22.2 No. 2556, or NMX-J-191-ANCE.

5.13 Hot-creep elongation and hot-creep set

5.13.1 Hot-creep elongation and hot-creep set of EP and EPCV insulation shall not exceed 50 percent and 5 percent, respectively, after conditioning at $150 \pm 2^{\circ}\text{C}$ ($302.0 \pm 3.6^{\circ}\text{F}$) for 15 min in an air oven. Compliance shall be determined in accordance with the test, Hot creep elongation and hot creep set, in UL 2556, CSA C22.2 No. 2556, or NMX-J-432-ANCE.

5.13.2 In Mexico, hot-creep elongation and hot-creep set of XL insulation shall not exceed 175 percent and 10 percent, respectively, after conditioning at $150 \pm 2^{\circ}\text{C}$ ($302.0 \pm 3.6^{\circ}\text{F}$) for 15 minutes in an air oven.

In Canada and the United States, this requirement does not apply.

5.14 Flame and smoke

5.14.1 FT2/FH/Horizontal Flame (XHH, XHHW, XHHW-2, RHH, RHW, RHW-2, SA, SF, and SIS, and Non XL Insulated Types R90, RW75, RW90, RWU75, and RWU90)

5.14.1.1 A finished wire or cable of any construction shall not convey flame along its length or to combustible materials in its vicinity when a specimen is subjected to the test, FT2/FH/Horizontal flame, in UL 2556, CSA C22.2 No. 2556, or NMX-J-192-ANCE. The total length of char on the specimen shall not exceed 100 mm (4 in), and the dripping particles emitted by the specimen during or after the application of flame shall not ignite the cotton on the floor of the enclosure, on the base of the burner, or on the wedge. Flameless charring of the cotton shall be ignored.

5.14.1.2 Type SIS conductors that comply with the requirements of [5.14.1.1](#) may be marked FT2.

5.14.2 Burning particles (dropping) (R90, RW75, RW90, RWU75, and RWU90) – with XL insulation only

XL insulation shall be such that when a specimen of single-conductor wire or cable without a covering or jacket is subjected to the test, Burning particles (dropping), in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE, burning particles from the specimen shall not cause the newsprint to ignite (flame). The specimen shall be tested after allowing at least 3 weeks after manufacture. Earlier testing by the manufacturer is optional.

5.14.3 FT1 (optional)

5.14.3.1 A finished conductor shall be considered to have met the requirements for this marking if:

- a) It does not convey flame.
- b) It does not continue to burn for more than 60 s after five 15 s applications of flame in the standard vertical flame test.
- c) The extended portion of the indicator is not burned more than 25 percent.

5.14.3.2 Compliance shall be determined in accordance with the test, FT1, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.14.4 FV-2/VW-1 vertical specimen (optional)

For a given size of a finished wire or cable to be marked VW-1 or FV-2, that size and 2.08 mm^2 (14 AWG) copper or 3.31 mm^2 (12 AWG) aluminum shall comply with the requirements of the horizontal flame test described in [5.14.1](#), and with this requirement when tested in accordance with the test, FV-2/VW-1, in UL

2556, CSA C22.2 No. 2556, or NMX-J-192-ANCE. Each specimen shall be judged capable of not conveying flame along its length or in its vicinity based on the following conditions:

- a) The specimen does not show 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 area shall be ignored) after any of the five applications of flame;
- b) The specimen does not emit 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); and
- c) The specimen does not continue to flame longer than 60 seconds after any application of the gas flame.

5.14.5 Vertical-tray (optional)

Finished wires or cables shall not exhibit damage that reaches the upper end of any of two sets of specimens when subjected to the test, Vertical tray flame tests (Method 1 – vertical tray), in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE.

5.14.6 FT4 vertical-tray (optional)

Finished wires or cables shall not exhibit charred material beyond a length exceeding 1.5 m (5 ft) from the lower edge of the burner face when subjected to the test, Vertical tray flame tests (Method 2 – FT4), in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE. Conductors complying with this requirement need not be subjected to the test described in [5.14.5](#).

5.14.7 ST1 limited smoke (optional)

5.14.7.1 General

5.14.7.1.1 When subjected to the test, ST1 limited smoke, in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE, each finished insulated single conductor shall comply with the requirements in [5.14.5](#) or [5.14.6](#). Limits are specified for each fire test to make the following tests equally acceptable for the purpose of quantifying the generation of smoke. The cable manufacturer shall specify, for testing each "ST1" (limited smoke) cable construction, the vertical flame exposure referenced in either [5.14.5](#) or [5.14.6](#).

5.14.7.1.2 For a range of sizes to be marked "ST1", typically the smallest conductor in the range, the smallest conductor employing the same insulation thickness as the largest conductor in the range, and an intermediate conductor shall be selected for testing. Individual conductor sizes may be tested.

5.14.7.2 Vertical-tray flame exposure

Finished wires or cables shall exhibit the following properties when subjected to the test, Vertical tray flame tests (Method 1 – vertical tray), in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE:

- a) The cable damage height for each set of specimens shall be less than 2.44 m (8 ft) when measured from the bottom of the cable tray;
- b) The total smoke released in 20 min for each set of specimens shall not exceed 95 m²;
- c) The peak smoke release rate for each set of specimens shall not exceed 0.25 m²/s; and
- d) The values of cable damage height, total smoke released, and peak smoke release rate obtained from one set of specimens shall not differ by more than 15 percent from the values

obtained from the second set of specimens. If any of the values differ by more than 15 percent between the two sets of specimens, a third set of specimens shall be tested. The values obtained from the third set of specimens shall be within the limits in items (a), (b), and (c).

5.14.7.3 FT4 vertical-tray flame exposure

Finished wires or cables shall exhibit the following properties when sets of specimen lengths are subjected to the test, Vertical tray flame tests (Method 2 – FT4), in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE:

- a) The cable damage height for each set of specimens shall be less than 1.50 m when measured from the lower edge of the burner face.
- b) The total smoke released in 20 minutes for each set of specimens shall not exceed 150 m².
- c) The peak smoke release rate for each set of specimens shall not exceed 0.40 m²/s.
- d) The values of cable damage height, total smoke released, and peak smoke release rate obtained from one set of specimens shall not differ by more than 15 percent from the values obtained from the second set of specimens. If any of the values differ by more than 15 percent between the two sets of specimens, a third set of specimens shall be tested. The values obtained from the third set of specimens shall be within the limits in items (a), (b), and (c).

5.14.8 LS (low smoke): Flame, smoke, and acid gas release (optional)

5.14.8.1 General

The requirements of [5.14.8.2](#) – [5.14.8.4](#) apply to types marked "LS".

5.14.8.2 Smoke emission

The components of cables shall be subjected to the test, Smoke emission, in UL 2556, CSA C22.2 No. 2556, or NMX-J-474-ANCE, to obtain the smoke emission performance. For cables up to 10 mm (0.40 in) external diameter, the maximum specific optical density (DM) shall not be more than 500, and the value of smoke obscuration in the first four min (VOF₄) shall not be more than 400. For cables with an external diameter larger than 10 mm (0.40 in), the maximum specific optical density (DM) shall not be more than 500, and the value of smoke obscuration in the first four minutes (VOF₄) shall not be more than 800. Tests shall be performed on die-cut specimens 2 mm ±0.02 (0.08 ±1 percent inch) in thickness.

5.14.8.3 Fire propagation/RPI

Finished wires or cables shall not exhibit a length of degradation that exceeds the upper limit of the test chimney (0.80 m over the oven), when subjected to the test, Fire propagation/RPI, in UL 2556, CSA C22.2 No. 2556, or NMX-J-093-ANCE.

5.14.8.4 Halogen acid gas emission

Samples of nonmetallic components of cables shall have a maximum loss of mass in the form of acid gas emission not greater than 20 percent (by weight) of halogen acid gas (except hydrogen fluoride), produced by pyrolysis. Compliance shall be determined in accordance with the test, Halogen acid gas emission, in UL 2556, CSA C22.2 No. 2556, or NMX-J-472-ANCE.

5.15 Weather (sunlight) resistance (optional)

5.15.1 In the United States and Mexico: to be marked SR, materials shall retain 80 percent of their initial tensile strength and elongation values after being subjected to 720 hours xenon or carbon arc exposure in accordance with the test, Physical properties (ultimate elongation and tensile strength) – Weather (sunlight) resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-553-ANCE.

In Canada: To be marked SR, materials shall retain 80 percent of their initial tensile strength and elongation values after being subjected to 1000 hours xenon arc exposure in accordance with the test, Physical properties (ultimate elongation and tensile strength) – Weather (sunlight) resistance, in UL 2556 and CSA C22.2 No. 2556. In addition, following the 1000-hour xenon-arc exposure described above, the sample shall comply with the requirements in [5.11.1](#) at minus 25°C in accordance with the test, Cold Bend, in UL 2556 and CSA C22.2 No. 2556.

5.15.2 In the United States: XL material containing a minimum of 2.0 percent carbon black measured to a depth of at least 0.76 mm (0.030 in) need not be tested in accordance with [5.15.1](#). The carbon black content shall be determined in accordance with the test, Carbon black content, in UL 2556 and CSA C22.2 No. 2556, and shall have a particle size of 35 nm or less. The carbon black shall be C or higher with an agglomerate size of 2 or less as measured in accordance with ASTM D2663, Test Method B – Agglomerate Method.

In Canada, XL material containing a minimum of 2.0 percent carbon black measured to a depth of at least 0.76 mm (0.030 in) or to a depth of 50 percent of the minimum average thickness whichever is greater need not be tested in accordance with [5.15.1](#). The carbon black content shall be determined in accordance with the test, Carbon black content, in UL 2556 and CSA C22.2 No. 2556, and shall have a particle size of 35 nm or less.

In Mexico, this requirement does not apply.

5.16 Oil resistance (optional)

5.16.1 Oil resistance at 60°C

To be marked PR I, the tensile strength and elongation of the insulation of a non-jacketed insulated conductor, or the jacket of a jacketed conductor or cable shall not be less than 50 percent of the unconditioned value after immersion of the finished wire in IRM 902 oil for 96 hours at 100°C. Compliance shall be determined in accordance with the test, Physical properties (ultimate elongation and tensile strength) – Oil resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-194-ANCE.

5.16.2 Oil resistance at 75°C

To be marked PR II, in addition to complying with the requirements of [5.14.1](#), the tensile strength and elongation of the insulation of a non-jacketed insulated conductor, or the jacket of a jacketed conductor or cable, shall not be less than 65 percent of the unconditioned value after immersion of the finished wire in IRM 902 oil for 60 d at 75°C. Compliance shall be determined in accordance with the test, Physical properties (ultimate elongation and tensile strength) – Oil resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-194-ANCE.

5.17 Gasoline and oil resistance (optional)

To be marked GR I or GR II, the insulation, of a non-jacketed insulated conductor, or the jacket of a jacketed conductor or cable, shall comply with the requirements of [5.16.1](#) or [5.16.2](#), respectively, and shall retain not less than 65 percent of their original tensile strength and elongation after 30 d immersion in water saturated with equal volumes of iso-octane and toluene (ASTM Reference Fuel C) maintained at 23

±1°C, in accordance with the test, Physical properties (ultimate elongation and tensile strength) – Gasoline resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-194-ANCE.

5.18 Crushing resistance

5.18.1 An average of not less than 5338 N (1200 lbf) shall be necessary to crush finished solid 2.08 mm² (14 AWG) Type XHH, XHHW, and XHHW-2 wires, and/or not less than 8007 N (1800 lbf) to crush finished stranded 33.6 mm² (2 AWG) Type XHH, XHHW, and XHHW-2 wires, to the point that the conductor contacts the earth-grounded metal of the testing machine used in the test, Crush resistance, Method 1 (two steel plates), in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.18.2 The results of this test on 2.08 mm² (14 AWG) and 33.6 mm² (2 AWG) sizes shall be considered representative of the performance of all 2.08 – 1010 mm² (14 AWG – 2000 kcmil) Type XHH, XHHW, and XHHW-2 wires with the same insulation.

5.19 Dielectric breakdown after glancing impact

The average breakdown potential for six specimens of finished solid 2.08 mm² (14 AWG) Type XHH, XHHW, and XHHW-2 wires that have separately been subjected to a glancing impact of 2 J (18 in-lbf) shall not be less than 20 percent of the average breakdown potential of six adjacent specimens of the same wire not subjected to the impact. Compliance shall be determined in accordance with the test, Dielectric breakdown after glancing impact, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.20 Durability of ink printing

Printing on the finished wire shall remain legible after being subjected to the test, Durability of ink printing, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE. One of the specimens shall be aged in a full-draft circulating-air oven with 100 – 200 fresh-air changes per hour, operating for the time and at the temperature specified for the insulation or jacketing material whose outer surface is printed, and shall then be removed from the oven and kept in still air to cool to room temperature for 60 min before being tested. The temperature and time for accelerated aging in circulating-air oven for conditioning of the insulation is indicated in [Table 11](#) and conditioning for the jacket in [Table 21](#). The one remaining specimen shall rest for at least 24 h in still air at 23.0 ±5.0°C (73.4 ±9.0°F) before being tested.

5.21 Shrinkback

This requirement applies to solid 2.08 – 5.26 mm² (14 – 10 AWG) XL insulated conductors only. No exposed end of the conductor shall exceed 3 mm (0.12 in) in length after 24 h when subjected to the test, Shrinkback, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE. As an option, if the exposed conductor length exceeds 3 mm (0.12 in), it shall not exceed 4 mm (0.16 in) in length after 7 d.

5.22 Evaluation of new materials – establishment of temperature rating

For the insulation and jacketing materials identified in [4.10](#), the projected elongation of the insulation and jacket shall not be less than 50 percent, and the projected tensile strength calculated for 300 d shall not be less than 2 MPa (300 lbf/in²) for jacketed insulation, and 4 MPa (600 lbf/in²) for unjacketed insulation and jackets, after being subjected to long-term aging in an air oven for a minimum of 150 d, in accordance with the test, Dry temperature rating of new materials (long-term aging test), in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

5.23 AC spark test

5.23.1 Every finished production length of single-conductor cable shall be subjected either:

- a) To the AC spark test in accordance with [5.23.2](#); or
- b) To the Dielectric voltage-withstand in water test described in [5.24](#) and the Insulation resistance in water at 15°C test described in [5.25](#).

In the event that option (a) is chosen, the finished wire or cable shall be capable of complying with the tests referred to in option (b).

5.23.2 The test shall be performed in accordance with the test, Spark, in UL 2556, CSA C22.2 No. 2556, or NMX-J-473-ANCE. The test potential shall be as shown in [Table 43](#).

5.24 Dielectric voltage-withstand in water

5.24.1 Finished wires or cables shall withstand, without breakdown of the insulation, the application of the appropriate test voltage after immersion in water for not less than 6 h before the test potential is applied, as follows:

- a) Wires or cables shall be subjected to the AC test voltage of [Table 44](#) for 60 s.
- b) Alternatively, wires and cables shall be subjected to a DC test voltage of 3 times the AC voltage specified in item (a) for the same period.

5.24.2 Compliance shall be determined in accordance with the test, Dielectric voltage-withstand, Method 1 (in water), in UL 2556, CSA C22.2 No. 2556, or NMX-J-293-ANCE.

5.25 Insulation resistance in water at 15°C

Following compliance with [5.24](#) while still immersed, the insulation of single conductors shall have an insulation resistance corrected to 15°C, if necessary, of not less than the values specified in [Table 45](#) – [Table 47](#) inclusive. Compliance shall be determined in accordance with the test, Insulation resistance, Method 1 (15°C in water), in UL 2556, CSA C22.2 No. 2556, or NMX-J-294-ANCE. Unless the spark test specified in [5.23](#) is carried out, each length of finished cable shall be subjected to this test.

5.26 Electrical continuity

Each conductor shall be continuous. Compliance shall be determined in accordance with the test, Continuity, Method 1 (general) or Method 2 (eddy current), in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

6 Marking

Advisory Note: In Canada, there are two official languages, English and French, and in Mexico, the official language is Spanish. Annex J provides translations in French and Spanish of the English markings specified in this Standard. Markings required by this Standard may have to be provided in other languages to conform with the language requirements of the country where the product is to be used.

6.1 Marking on product

6.1.1 General

6.1.1.1 All markings on the finished product shall be visible and legible. Surface printing, indent printing, or embossed marking meet the intent of this requirement. The process shall not result in a thickness less than the minimum specified.

6.1.1.2 The marking legend shall be repeated at intervals not exceeding 1.0 m (40 in), except for conductor size, which shall be repeated on the conductor or marker tape at intervals not exceeding 610 mm (24 in).

6.1.1.3 For products intended for specific national applications, markings alternative to those in this requirement are described in Annex J.

6.1.1.4 Required markings are described in 6.1.2 – 6.1.8. Optional markings are described in 6.1.9 – 6.1.14.

6.1.1.5 Markings on a product shall be optional when the product is intended for further processing into another cable product.

6.1.2 Manufacturer's identification

A finished wire or cable shall have a durable distinctive marking throughout its entire length by which the organization responsible for the product is readily identified.

6.1.3 Type designation

6.1.3.1 The type designation as described in Table 1 shall be marked as indicated in 6.1.1. The use of the word "Type" shall be optional. Marking of the maximum operating dry and wet temperature rating of insulation, as applicable, shall be optional.

6.1.3.2 Multiple-conductor cables with Type RHH, RHW, RHW-2, SA, XHH, XHHW, or XHHW-2 conductors and an outer covering over the assembly shall have a suffix after the type letters as follows:

- a) D – Cable in which two conductors are laid parallel; or
- b) M – Cable in which two or more conductors are cabled together.

6.1.3.3 A wire or cable that complies with all of the requirements applicable to two or more types shall be allowed to be marked to so indicate, for example "R90 or XHHW".

6.1.4 Conductor size

The size of conductors shall be marked on the product, expressed in one or more of the following forms:

- a) mm² (AWG);
- b) AWG (mm²);
- c) mm² (kcmil);
- d) kcmil (mm²);
- e) AWG; or
- f) kcmil.

In Mexico, items (a) and (c) apply.

In Canada, items (a), (b), (c), and (d) apply.

In the United States, items (a), (b), (c), (d), (e) and (f) apply.

The use of either a comma or a period signifies a decimal. For printing on products, the use of "mm2" in place of "mm²" shall be allowed.

The nominal cross-sectional area in square millimeters shall be as shown in [Table 5](#).

6.1.5 Conductor stranding

A wire or cable employing stranded conductors that are more finely stranded than Class B or C stranding (including Class B and Class C compact) shall be marked with the conductor class or classes. For conductor class, refer to [4.1](#). For the number of strands on Class B or C conductors, see [Table 49](#).

Note: A wire or cable employing SIW or combination unilay stranding need not be marked.

6.1.6 Aluminum conductors

6.1.6.1 AA 8000 conductors shall be marked "AL". The additional marking "ACM" or "AA 8000" shall be optional.

6.1.6.2 Conductors of 1350 aluminum alloy shall be marked "AL 1350".

6.1.7 Compact copper conductors

In the United States, compact-stranded copper conductors shall be marked "Compact Copper" or "Compact Cu" or "Cmpct Cu" after the conductor size.

In Canada and Mexico, this requirement does not apply.

6.1.8 Voltage marking

A wire or cable shall be marked with its voltage rating(s), using "V", "volts", or "VOLTS".

6.1.9 Low-temperature marking (optional)

A wire or cable complying with the requirements for minus 40°C cold bend and cold impact specified in [5.11](#) may be marked "(-40C)".

6.1.10 Flame test marking (optional)

6.1.10.1 General

Insulated conductors with the following markings shall have met the requirements of the corresponding clauses:

- a) "FT1": [5.14.3](#) applies;
- b) "FV2" or "VW-1": [5.14.4](#) applies;
- c) "CT": [5.14.5](#) or [5.14.6](#) applies (see [6.1.10.2](#) for applicability);

- d) "FT4" or "FT4/IEEE 1202": [5.14.6](#) or [5.14.7](#) apply using flame exposure in accordance with the test, Vertical tray flame tests (Method 2-FT4), in UL 2556, CSA C22.2 No. 2556, or NMX-J-498-ANCE;
- e) "ST1": [5.14.7](#) applies;
- f) "LS": [5.14.8](#) applies;
- g) "RPI": [5.14.8.3](#) applies; and
- h) "FT2": [5.14.1](#) applies.

Note: The FT1 or FT4 marking is required where specified in the CE Code, Part I, and the National Building Code of Canada.

6.1.10.2 Cable tray use marking (optional)

6.1.10.2.1 Insulated conductors marked "CT" shall comply with the requirements of either [5.14.5](#) or [5.14.6](#).

6.1.10.2.2 In the United States, this marking shall be allowed on single circuit conductors of size 53.5 mm² (1/0 AWG) and larger, and on equipment-grounding conductors of size 21.2 mm² (4 AWG) and larger.

In Mexico, the marking "CT" shall be allowed on all sizes of multiple conductors and to single circuit conductors 21.2 mm² (4 AWG) and larger.

In Canada, the marking "CT" is not recognized by the CE Code, Part I.

6.1.11 Weather resistance

Wires or cables complying with the requirements of [5.15](#) may be marked "SR".

6.1.12 Oil resistance

Wires or cables complying with the requirements of [5.16.1](#) may be marked "PR I". Wires or cables complying with the requirements of [5.16.2](#) may be marked "PR II".

6.1.13 Gasoline and oil resistance

Wires or cables complying with the requirements of [5.16.1](#) and [5.17](#) may be marked "GR I". Wires or cables complying with the requirements of [5.16.2](#) and [5.17](#) may be marked "GR II".

6.1.14 Shielded products

Products complying with the requirements of [4.4](#) shall be marked "SHIELDED".

6.2 Marking on package

Each package of wire or cable shall be tagged or marked to indicate the following legibly:

- a) Manufacturer's identification;
- b) Date of manufacture, by month and year (a code is acceptable);
- c) Type designation;

- d) Conductor size in accordance with [6.1.4](#);
- e) "AL" after the conductor size [item (d) above], when an AA 8000 conductor is used. The additional markings "ACM" or "AA 8000" shall be optional. If conductors of 1350 aluminum alloy are used, "1350" shall follow "AL". If compact stranding is used, "CMPCT" or the word "COMPACT" shall accompany "AL" or "ACM";
- f) Voltage rating(s);
- g) In the United States, if stranded copper conductors are compact, the words "Compact Copper" or "Compact Cu" or "Cmpct Cu" shall appear after the conductor size [item (d) above]. The following statement shall also appear on the package: "Terminate with connectors identified for use with compact-stranded copper conductors";
- h) "SHIELDED" when applicable;
- i) Optionally, the maximum operating dry and wet temperature rating of insulation; and
- j) For cables not marked "SR", the statement indicated in Annex [J](#): "CAUTION: PROTECT CABLES OR WIRES ON REELS AGAINST EXPOSURE TO SUNLIGHT WHEN LEFT OUTDOORS". Annex [J](#) provides translations in French and Spanish of this English language marking.

7 Deep-Well Submersible Water-Pump Cable

7.1 General

The construction of deep-well submersible water-pump cable shall consist of assemblies comprising two or more insulated circuit conductors having a wet rating and an optional insulated equipment-grounding conductor. The assemblies shall be with or without an overall jacket. Either twisted or parallel configurations shall be permitted.

In the United States and Mexico, a low-temperature rating of minus 40°C shall be optional.

In Canada, the minus 40°C rating is required as specified in the CE Code, Part I.

7.2 Construction

7.2.1 General

Except as indicated, the components of deep-well submersible water-pump cable shall comply with the requirements of [7.2](#) – [7.4](#) of this Standard.

7.2.2 Conductors

Circuit conductors shall consist of solid or stranded 2.08 – 33.6 mm² (14 – 2 AWG) copper, solid or stranded 3.31 – 33.6 mm² (12 – 2 AWG) aluminum, or stranded 42.4 – 253 mm² (1 AWG – 500 kcmil) copper or aluminum. The optional insulated equipment-grounding conductor shall be of the same construction as the circuit conductors, except that a copper equipment-grounding conductor shall be allowed with aluminum circuit conductors, or an aluminum equipment-grounding conductor shall be allowed with copper circuit conductors. The minimum sizes of equipment-grounding conductors shall be as specified in [Table 26](#). All conductors shall comply with [4.1](#) of this Standard.

7.2.3 Insulation

Insulated conductors shall be of the types provided in [7.2.4](#).

7.2.4 Assembly

The conductors shall be assembled in one of the following ways:

a) CABLED WITH AN OVERALL JACKET – This cable assembly shall have two or more insulated circuit conductors of one of the following types: RHW-2, XHHW-2, RHW, XHHW, RWU75, or RWU90. The insulated circuit conductors shall be cabled together with an optional insulated equipment-grounding conductor in either a right- or left-hand lay of unspecified length, with an overall jacket. The jacket shall comply with the thickness requirements of [Table 48](#) and the physical properties requirements in [Table 21](#).

b) CABLED WITHOUT AN OVERALL JACKET – This cable assembly shall have 2 – 6 insulated circuit conductors of one of the following types: RHW-2, XHHW-2, RHW, XHHW, RWU75, or RWU90. The insulated conductors shall be cabled together helically with an optional insulated equipment-grounding conductor in either a right- or left-hand lay of unspecified length, without an overall jacket.

c) PARALLEL WITH INTEGRAL WEB WITHOUT AN OVERALL JACKET – This cable assembly shall have two, three, or four circuit conductors of one of the following types: RHW-2, XHHW-2, RHW, XHHW, RWU75, or RWU90. The circuit conductors shall be laid flat and parallel together with any optional equipment-grounding conductor laid parallel on the same axis. The conductors shall be joined to one another with an interconnecting web. The conductor insulation shall be extruded simultaneously with the interconnecting web and shall be of the same compound. The minimum thickness of insulation at any point on any conductor, after separation, shall not be less than required for the specified wire type.

d) PARALLEL WITH AN OVERALL JACKET AND INTEGRAL FILLERS OR WEBS – This cable assembly shall have two, three, or four insulated circuit conductors of the following types: RHW-2, XHHW-2, RHW, XHHW, RWU75, or RWU90. The circuit conductors shall be laid parallel on the same axis, together with an optional insulated equipment-grounding conductor, and having an overall jacket that shall be extruded to form either an interconnecting web of unspecified thickness between the conductors, or fillers that are integral with the jacket. The degree to which the integral fillers fill the valleys between the conductors is not specified, except that the fill shall maintain the stability of the flat construction.

7.2.5 Polarity identification of conductors

7.2.5.1 Polarity identification of conductors other than the grounding or grounded conductor shall be provided by means of contrasting colors or stripes other than white, gray, or green; by ridges; by stripes; or by word printing. Grounded circuit conductors shall be colored white or gray or shall have white or gray stripes.

In Canada, the color of the conductors shall also be in accordance with Annex [H](#).

In Mexico and the United States, the requirements in Annex [H](#) do not apply.

7.2.5.2 The equipment-grounding conductor shall be colored green or green with yellow stripes.

7.2.5.3 In the case of a flat cable that includes an insulated equipment-grounding conductor, the grounding conductor shall be identified as such, either as indicated in [7.2.5.1](#) or by means of legible, durable ink printing of "GROUNDING ONLY" or equivalent on the outer surface of the finished conductor.

7.2.6 Jackets

7.2.6.1 Jackets shall comply with the requirements of [4.9.1](#).

7.2.6.2 The average and minimum thickness of a jacket shall not be less than indicated in [Table 48](#) when determined by the method described in the test, Thickness, in UL 2556, CSA C22.2 No. 2556, or NMX-J-177-ANCE. The diameter over the assemblies described in [7.2.4](#), for the purpose of determining jacket thickness, shall be obtained as specified in [4.9.3](#).

7.3 Markings

Advisory Note: In Canada, there are two official languages, English and French, and in Mexico, the official language is Spanish. Annex J provides translations in French and Spanish of the English markings specified in this Standard. Markings required by this Standard may have to be provided in other languages to conform with the language requirements of the country where the product is to be used.

7.3.1 Markings on product

7.3.1.1 Deep-well submersible water-pump cable shall be legibly and durably marked to indicate the following:

- a) The manufacturer's identification in accordance with [6.1.2](#);
- b) The number of circuit conductors (in the case of jacketed constructions);
- c) The conductor size in accordance with [6.1.4](#);
- d) The word "AL", if aluminum conductors are used. The additional marking "ACM" shall be optional;
- e) The designation "SUBMERSIBLE PUMP CABLE", "CABLE BOMBA SUMERGIBLE", or "CÂBLE POUR POMPE SUBMERSIBLE", as applicable;
- f) The nominal voltage rating in accordance with [6.1.8](#);
- g) The low-temperature rating marking in accordance with [6.1.9](#) for cables complying with [7.4.3](#);
- h) The type designation of individual conductors, either on the conductor insulation surface or the outer jacket. Marking of the maximum operating dry and wet temperature rating of insulation, as applicable, shall be optional; and
- i) Optional markings specified in [6.1](#) as applicable.

7.3.1.2 The markings in [7.3.1.1](#) shall be surface ink-printed, indented, or embossed at intervals not exceeding 0.6 m (24 in). Indent markings shall be such that the minimum specified thickness of the jacket or insulation is maintained.

7.3.1.3 For products intended for specific national applications, markings alternative to those in this requirement are described in Annex J.

7.3.2 Markings on package

Each packaged coil or reel of cabled or parallel assembly, and of jacketed cables, shall be tagged or marked to indicate the following legibly:

- a) The manufacturer's identification in accordance with [6.1.2](#);
- b) The month and year of manufacture;
- c) The designation "SUBMERSIBLE PUMP CABLE";
- d) The conductor size in accordance with [6.1.4](#);
- e) "AL" or "ALUM", if aluminum conductors are used. The additional marking "ACM" shall be permitted;
- f) The nominal voltage rating in accordance with [6.1.8](#);
- g) The low-temperature rating marking in accordance with [6.1.9](#) for cables in compliance with [7.4.3](#);
- h) In the United States and Canada, the notation "For Wiring Only Between Equipment Located at Water Well Heads and Motors of Installed Deep-Well Submersible Water Pumps";

In Mexico, this requirement does not apply; and
- i) The type designation of the individual conductors. Marking of the maximum operating dry and wet temperature rating of insulation, as applicable, shall be optional.

For products intended for specific national applications, markings alternative to those in this requirement are described in Annex [J](#).

7.4 Tests

7.4.1 General

In addition to the tests performed on each insulated conductor according to its type as specified in Test Requirements, Section [5](#), and the spark test specified in [Table 43](#), the completed cable shall be subjected to the tests in [7.4.2](#) – [7.4.4](#).

7.4.2 Dielectric withstand

7.4.2.1 A finished assembly or cable shall withstand the AC voltage as specified in [5.24](#). For a flat or twisted assembly, the test voltage shall be applied between each conductor while the assembly is immersed in tap water. Flat assemblies shall be immersed for 6 h, twisted assemblies for 1 h. Spark testing in accordance with [5.23](#) is also acceptable.

7.4.2.2 Cable with an overall jacket shall not be immersed in water. The test voltage shall be applied to each conductor in turn, while the remaining conductors are connected together and connected to ground.

7.4.3 Cold impact

A cabled assembly with Type RWU75 or RWU90 conductors, when tested individually, shall comply with the requirements in [5.11.2](#). A cable with an overall jacket shall comply with the requirements of [5.11.2](#).

7.4.4 Electrical continuity

Each conductor shall be continuous when tested in accordance with the test, Continuity, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

TABLES

Table 1
Summary of the types, maximum conductor temperature, voltage ratings, and number of insulated conductors

(See [1.2](#), [6.1.3.1](#), and Annexes [B](#) and [K](#))

Type letter designation	Voltage rating, V	Temperature rating	Number of conductors ^a
XHHW-2	600 or 1000 ^c	90°C wet or dry	1, 2 parallel, 2 or more cabled
XHHW	600 or 1000 ^c	75°C wet and 90°C dry	1, 2 parallel, 2 or more cabled
XHH	600 or 1000 ^c	90°C dry	1, 2 parallel, 2 or more cabled
RHH	600 or 1000 ^c or 2000	90°C dry	1, 2 parallel, 2 or more cabled
RHW-2	600 or 1000 ^c or 2000	90°C wet or dry	1, 2 parallel, 2 or more cabled
RHW	600 or 1000 ^c or 2000	75°C wet or dry	1, 2 parallel, 2 or more cabled
SA	600 or 1000 ^c	90°C dry 200°C for special applications	1, 2 parallel, 2 or more cabled
SF	600	90°C dry 200°C for special applications	1, 2 parallel, 2 or more cabled
SIS	600 or 1000 ^c	90°C dry	1
R90	600, 1000, 2000, or 5000 ^b	90°C dry	1, 2 parallel, 2 or more cabled
RW75	600, 1000, 2000, or 5000 ^b	75°C wet or dry	1, 2 parallel, 2 or more cabled
RW90	600, 1000, 2000, or 5000 ^b	90°C wet or dry	1, 2 parallel, 2 or more cabled
RWU75	1000	75°C wet or dry	1, 2 parallel, 2 or more cabled
RWU90	1000	90°C wet or dry	1, 2 parallel, 2 or more cabled

^a See Deep-Well Submersible Water-Pump Cable, Section [Z](#) for deep-well submersible pump cable constructions.

^b In Canada, requirements for 5000 V rated types are obtained from Annex [K](#).

^c Applies to the United States only.

In Mexico and the United States, the requirements in Annex [K](#) do not apply.

Table 2
Conductors

(See 4.1.5.1.1, D.2, and Annex B)

Wire type	Metal	Conductor size range		Type of stranding
		mm ²	AWG or kcmil	
XHHW-2, XHHW, XHH, RHH, RHW, RHW-2, R90, RW75, RW90, RWU75, RWU90, SIS ^a , SA, or SF	Copper	2.08 – 1010	14 – 2000	Concentric, compressed, rope lay, and bunched
		8.37 – 507	8 – 1000	Compact
		2.08 – 107	14 – 4/0	Solid, and combination unilay
XHHW-2, XHHW, XHH, RHH, RHW, RHW-2, R90, RW75, RW90, RWU75, RWU90, SIS ^a	Aluminum	3.31 – 1010	12 – 2000	Concentric, compressed rope lay, and bunched
		8.37 – 507	8 – 1000	Compact
		3.31 – 107	12 – 4/0	Solid
		13.3 – 107	6 – 4/0	Combination unilay

^a Type SIS is limited to 2.08 – 107 mm² (14 – 4/0 AWG) copper and 3.31 – 107 mm² (12 – 4/0 AWG) aluminum. Conductor sizes 42.4 mm² (1 AWG) and larger shall be stranded.

Table 3
Conductor stranding

(See 4.1.5.2, D.2, and Annex B)

Conductor size		Number of strands in combination unilay	Minimum number of strands ^b	
mm ²	AWG or kcmil		Compact stranded	All others
2.08 – 8.37	14 – 8	19 ^a	7	7
13.3 – 33.6	6 – 2	19	7	7
42.4 – 107	1 – 4/0	19	18	19
127 – 253	250 – 500	–	35	37
279 – 507	550 – 1000	–	58	61
557 – 760	1100 – 1500	–	–	91
811 – 1010	1600 – 2000	–	–	127
^a Copper only.				
^b In Canada and the United States, single input wire strands shall be in accordance with ASTM B801, ASTM B835, ASTM B836, ASTM B901, and ASTM B902. In Mexico, the lesser number of strands in a conductor shall be as shown in this Table or as specified in NMX-J-012-ANCE or NMX-J-014-ANCE as applicable.				

Table 4
Length of lay of strands in a bunch-stranded conductor twisted as a single bunch^a

(See 4.1.5.6)

Size of conductor mm ² (AWG)	Maximum acceptable length of lay	
	mm	inches
2.08 (14)	41	1-5/8
3.31 (12)	51	2
5.26 (10)	64	2-1/2

Table 4 Continued on Next Page

Table 4 Continued

Size of conductor mm ² (AWG)	Maximum acceptable length of lay	
	mm	inches
8.37 (8)	70	2-3/4
13.3 (6)	86	3-3/8
Larger than 13.3 (6)	16 times the conductor diameter	

^a Includes the following bunch-stranded constructions twisted as a single bunch under Classes I, K, and M:

Conductor size		Number of strands in single bunch		
mm ²	AWG	Class I	Class K	Class M
2.08	14	—	41	104
3.31	12	—	65	—
5.26	10	26	104	—
8.37	8	41	—	—
13.3	6	65	—	—

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Table 5
Conductor diameter and cross-sectional area

(See [4.1.6.1](#), [4.1.6.2](#), [6.1.4](#), and Annex B)

Size of conductor		Nominal diameter of solid conductor		Nominal cross-sectional area of conductor	
mm ²	AWG or kcmil	mm	inch	mm ²	cmil or kcmil
2.08	14 AWG	1.63	0.0641	2.08	4110 cmil
3.31	12	2.05	0.0808	3.31	6530
5.26	10	2.588	0.1019	5.26	10380
8.37	8	3.264	0.1285	8.37	16510
13.3	6	4.115	0.1620	13.3	26240
21.2	4	5.189	0.2043	21.2	41740
26.7	3	5.827	0.2294	26.7	52620
33.6	2	6.543	0.2576	33.6	66360
42.4	1	7.348	0.2893	42.4	83690
53.5	1/0	8.252	0.3249	53.5	105600
67.4	2/0	9.266	0.3648	67.4	133100
85.0	3/0	10.40	0.4096	85.0	167800
107	4/0	11.68	0.4600	107	211600
127	250 kcmil	—	—	127	250 kcmil
152	300	—	—	152	300
177	350	—	—	177	350
203	400	—	—	203	400
228	450	—	—	228	450

Table 5 Continued on Next Page

Table 5 Continued

Size of conductor		Nominal diameter of solid conductor		Nominal cross-sectional area of conductor	
mm ²	AWG or kcmil	mm	inch	mm ²	cmil or kcmil
253	500	—	—	253	500
279	550	—	—	279	550
304	600	—	—	304	600
329	650	—	—	329	650
355	700	—	—	355	700
380	750	—	—	380	750
405	800	—	—	405	800
456	900	—	—	456	900
507	1000	—	—	507	1000
557	1100	—	—	557	1100
602	1200	—	—	608	1200
633	1250	—	—	633	1250
659	1300	—	—	659	1300
709	1400	—	—	709	1400
760	1500	—	—	760	1500
811	1600	—	—	811	1600
861	1700	—	—	861	1700
887	1750	—	—	887	1750
912	1800	—	—	912	1800
963	1900	—	—	963	1900
1010	2000	—	—	1010	2000

Table 6
Diameters of round compact-stranded conductors

(See [4.1.6.1](#) and Annex [B](#))

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
8.37	8 AWG	3.40	0.134
13.3	6	4.29	0.169
21.2	4	5.41	0.213
26.7	3	6.02	0.238
33.6	2	6.81	0.268
42.4	1	7.59	0.299

Table 6 Continued on Next Page

Table 6 Continued

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
53.5	1/0	8.53	0.336
67.4	2/0	9.55	0.376
85.0	3/0	10.74	0.423
107	4/0	12.07	0.475
127	250 kcmil	13.21	0.520
152	300	14.48	0.570
177	350	15.65	0.616
203	400	16.74	0.659
228	450	17.78	0.700
253	500	18.69	0.736
279	550	19.69	0.775
304	600	20.65	0.813
329	650	21.46	0.845
355	700	22.28	0.877
380	750	23.06	0.908
405	800	23.83	0.938
458	900	25.37	0.999
507	1000	26.92	1.060

Table 7
Diameters of round compressed concentric-lay-stranded Classes B, C, and D aluminum, uncoated copper, and coated copper conductors

(See [4.1.6.1](#) and Annex [B](#))

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
2.08	14 AWG	1.80	0.071
3.31	12	2.26	0.089
5.26	10	2.87	0.113
8.37	8	3.61	0.142
13.3	6	4.52	0.178
21.2	4	5.72	0.225
26.7	3	6.40	0.252
33.6	2	7.19	0.283
42.4	1	8.18	0.322

Table 7 Continued on Next Page

Table 7 Continued

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
53.5	1/0	9.19	0.362
67.4	2/0	10.0	0.405
85.0	3/0	11.6	0.456
107	4/0	13.0	0.512
127	250 kcmil	14.2	0.558
152	300	15.5	0.611
177	350	16.8	0.661
203	400	17.9	0.706
226	450	19.0	0.749
253	500	20.0	0.789
279	550	21.1	0.829
304	600	22.0	0.866
329	650	22.9	0.901
355	700	23.7	0.935
380	750	24.6	0.968
405	800	25.4	1.000
456	900	26.9	1.060
507	1000	28.4	1.117
557	1100	29.8	1.173
608	1200	31.1	1.225
633	1250	31.8	1.250
659	1300	32.4	1.275
709	1400	33.6	1.323
760	1500	34.8	1.370
811	1600	35.9	1.415
861	1700	37.1	1.459
887	1750	37.6	1.480
912	1800	38.2	1.502
963	1900	39.2	1.542
1010	2000	40.2	1.583

Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE for copper conductors, and NMX-J-032-ANCE for aluminum conductors.

Table 8
Diameters of round compressed single input wire and unidirectional or unilay stranded Class B
aluminum, uncoated copper, and coated copper conductors

(See [4.1.6.1](#) and Annex [B](#))

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
2.08	14 AWG	1.80	0.071
3.31	12	2.26	0.089
5.26	10	2.87	0.113
8.37	8	3.61	0.142
13.3	6	4.52	0.178
21.2	4	5.72	0.225
26.7	3	6.40	0.252
33.6	2	7.19	0.283
42.4	1 AWG	7.95	0.313
53.5	1/0	8.94	0.352
67.4	2/0	10.03	0.395
85.0	3/0	11.25	0.443
107	4/0	12.65	0.498
127	250 kcmil	13.77	0.542
152	300	15.09	0.594
177	350	16.28	0.641
203	400	17.40	0.685
226	450	18.47	0.727
253	500	19.46	0.766
279	550	20.42	0.804
304	600	21.34	0.840
329	650	22.20	0.874
355	700	23.04	0.907
380	750	23.85	0.939
405	800	24.61	0.969
456	900	26.11	1.028
507	1000	27.53	1.084
557	1100	28.88	1.137
608	1200	30.15	1.187
633	1250	30.78	1.212
659	1300	31.39	1.236
709	1400	32.56	1.282
760	1500	33.71	1.327
811	1600	34.82	1.371

Table 8 Continued on Next Page

Table 8 Continued

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
861	1700	35.89	1.413
887	1750	36.42	1.434
912	1800	33.71	1.327
963	1900	37.95	1.494
1010	2000	38.94	1.533

Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE for copper conductors, and ASTM B231/B231M or NMX-J-032-ANCE for aluminum conductors.

Table 9
Diameter of Class B, C, and D round concentric-lay-stranded conductors

(See [4.1.6.1](#) and Annex [B](#))

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
2.08	14 AWG	1.85	0.0727
3.31	12	2.32	0.0915
5.26	10	2.95	0.116
8.37	8	3.71	0.146
13.3	6	4.67	0.184
21.2	4	5.89	0.232
26.7	3	6.60	0.260
33.6	2	7.42	0.292
42.4	1	8.43	0.332
53.5	1/0	9.45	0.372
67.4	2/0	10.62	0.418
85.0	3/0	11.94	0.470
107	4/0	13.41	0.528
127	250 kcmil	14.6	0.575
152	300	16.00	0.630
177	350	17.30	0.681
203	400	18.49	0.728
228	450	19.61	0.772
253	500	20.65	0.813
279	550	21.72	0.855
304	600	22.68	0.893
329	650	23.60	0.929
355	700	24.49	0.964
380	750	25.35	0.998

Table 9 Continued on Next Page

Table 9 Continued

Conductor size		Nominal diameter	
mm ²	AWG or kcmil	mm	inch
405	800	26.16	1.030
456	900	27.79	1.094
507	1000	29.26	1.152
557	1100	30.71	1.209
608	1200	32.08	1.263
633	1250	32.74	1.289
659	1300	33.38	1.314
709	1400	34.67	1.365
760	1500	35.86	1.412
811	1600	37.06	1.459
861	1700	38.20	1.504
887	1750	38.76	1.526
912	1800	39.32	1.548
963	1900	40.39	1.590
1010	2000	41.45	1.632

Table 10
Strand and conductor dimensions of 19-wire combination round-wire unilay-stranded copper or aluminum conductors

(See 4.1.6.1 and Annex B)

Conductor size		Nominal strand dimensions								Nominal conductor diameter E = 3A + 2C	
		Large strand				Small strand					
		Diameter A		Cross-sectional area		Diameter C		Cross-sectional area			
mm ²	AWG	mm	inch	mm ²	cmil	mm	inch	mm ²	cmil	mm	inch
2.08	14	0.404	0.0159	0.128	253	0.3	0.0117	0.069	137	1.80	0.071
3.31	12	0.5	0.0201	0.205	404	0.4	0.0147	0.109	216	2.29	0.090
5.26	10	0.6	0.0253	0.324	640	0.5	0.0185	0.173	342	2.87	0.113
8.37	8	0.8	0.0319	0.515	1018	0.6	0.0234	0.277	548	3.63	0.143
13.3	6	1.0	0.0402	0.818	1616	0.7	0.0294	0.437	864	4.55	0.179
21.2	4	1.3	0.0507	1.301	2570	0.9	0.0371	0.696	1376	5.74	0.226
26.7	3	1.4	0.0570	1.644	3249	1.1	0.0417	0.880	1739	6.45	0.254
33.6	2	1.6	0.0640	2.073	4096	1.2	0.0468	1.108	2190	7.26	0.286
42.4	1	1.8	0.0718	2.609	5155	1.3	0.0526	1.400	2767	8.15	0.321
53.5	1/0	2.1	0.0807	3.296	6512	1.5	0.0591	1.768	3493	9.14	0.360
67.4	2/0	2.3	0.0906	4.154	8208	1.7	0.0663	2.225	4396	10.26	0.404
85.0	3/0	2.6	0.1017	5.234	10343	1.9	0.0745	2.809	5550	11.53	0.454
107	4/0	2.9	0.1142	6.600	13042	2.1	0.0836	3.537	6989	12.95	0.510

Table 11
Physical properties of insulation

(See 4.2.1.2, 4.10.1, 4.10.2, 5.7, 5.20, and Annex B)

Condition		Test		EP		XL		EPCV	
				RW75, RWU75, RHW	R90, RW90, RWU90, RHW-2, RHH	RW75, RWU75, RHW	R90, RW90, RWU90, RHH, XHH, XHHW, XHHW-2, RHW-2, SIS	RW75, RWU75, RHW	R90, RW90, RWU90, RHH, XHH, XHHW, XHHW-2, SIS
Before aging		Elongation, minimum		250 percent	250 percent	150 percent	150 percent	225 percent	225 percent
		Tensile strength, minimum, MPa (lbf/in ²)		4.8 MPa (700)	4.8 MPa (700)	10.3 MPa (1500)	10.3 MPa (1500)	8.3 MPa (1200)	8.3 MPa (1200)
After air oven accelerated aging		Tensile strength, minimum		110 ±1°C for 7 d 75 percent of unaged value	121 ±1°C for 7 d 75 percent of unaged value	113 ±1°C for 7 d 70 percent of unaged value	121 ±1°C for 7 d 70 percent of unaged value	110 ±1°C for 7 d 75 percent of unaged value	121 ±1°C for 7 d 75 percent of unaged value
		Elongation, minimum		75 percent of unaged value	75 percent of unaged value	70 percent of unaged value	70 percent of unaged value	75 percent of unaged value	75 percent of unaged value
Condition	Test	CP		CPE		SBR/IIR/NR		Silicone	
		RHW	RHW-2, RHH, SIS	RHW	RHW-2, RHH, SIS	RHW ^a	RHW-2 ^b , RHH ^b	RHH, RHW, RHW-2, R90, RW75, RW90	SA, SF
Before aging	Elongation, minimum	200 percent	200 percent	200 percent	250 percent	300 percent	300 percent	250 percent	250 percent
	Tensile strength, Minimum MPa (lbf/in ²)	10.3 (1500)	10.3 (1500)	10.3 (1500)	10.3 (1500)	4.8 (700)	4.8 (700)	5.5 (800)	5.5 (800)
Condition	Test	CP		CPE		SBR/IIR/NR		Silicone	
		RHW	RHW-2, RHH, SIS	RHW	RHW-2, RHH, SIS	RHW ^a	RHW-2 ^b , RHH ^b	RHH, RHW, RHW-2, R90, RW75, RW90	SA, SF
After air oven accelerated aging	Tensile strength, Minimum	113 ±1°C for 7 d 85 percent of unaged value	121 ±1°C for 7 d 85 percent of unaged value	113 ±1°C for 7 d 85 percent of unaged value	121 ±1°C for 7 d 85 percent of unaged value	100 ±1°C for 10 d 50 percent of unaged value	121 ±1°C for 7 d 70 percent of unaged value	136 ±1°C for 60 d 65 percent of unaged value	210 ±1°C for 60 d 60 percent of unaged value
	Elongation, minimum	50 percent of unaged value	50 percent of unaged value	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	75 percent of unaged value	75 percent of unaged value

Table 11 Continued on Next Page

Table 11 Continued

After immersion in oil		18 h @ 121 ±1°C	18 h @ 121 ±1°C	18 h @ 121 ±1°C	18 h @ 121 ±1°C	–	–	–	–
	Tensile strength, Minimum	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	–	–	–	–
	Elongation, minimum	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	60 percent of unaged value	–	–	–	–

^a The maximum set 25 mm (1 in) benchmarks stretched to 62.5 mm (2.5 in) is 25 percent.

^b The maximum set 25 mm (1 in) benchmarks stretched to 75 mm (3 in) is 25 percent.

Table 12
Thickness of insulation on 600 V or 1000 V^a Types XHHW-2, XHHW, XHH, and 600 V Types R90^b, RW75^b and RW90^b

(See [4.2.3](#), [Table 36](#), [Table 37](#), and [Table 46](#), and Annex B)

Size of conductor		mm		mils	
mm ²	AWG or kcmil	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
2.08 – 5.26	14 – 10 AWG	0.76	0.69	30	27
9.37 – 33.6	8 – 2	1.14	1.02	45	40
42.4 – 107	1 – 4/0	1.40	1.27	55	50
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	1.65	1.47	65	58
Larger than 253 – 507	Larger than 500 – 1000	2.03	1.83	80	72
Larger than 507 – 1010	Larger than 1000 – 2000	2.41	2.18	95	86

^a Applies to the United States only.

^b For types employing silicone insulation, see [Table 15](#).

Table 13
Thicknesses of insulation on 600 V Type SA and SF wires

(See [4.2.3](#), [Table 46](#), and Annex B)

Conductor size		mm		mils	
mm ²	AWG or kcmil	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
2.08 – 5.26	14 – 10	1.14	1.02	45	40
8.37 – 33.6	8 – 2	1.52	1.37	60	54
42.4 – 107	1 – 4/0	2.03	1.83	80	72
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	2.41	2.18	95	86
Larger than 253 – 507	Larger than 500 – 1000	2.79	2.51	110	99
Larger than 507 – 1010	Larger than 1000 – 2000	3.18	2.84	125	112

Table 14
Thicknesses of insulation on 600 V or 1000 V^a Type SIS wire

(See 4.2.3, Table 46, and Annex B)

Conductor size		mm		mils	
mm ²	AWG	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
2.08 – 5.26	14 – 10	0.76	0.69	30	27
8.37 – 33.6	8 – 2	1.14	1.02	45	40
42.4 – 107	1 – 4/0	1.40	1.27	55	50

^a Applies to the United States only.

Table 15
Thickness of insulation on 600 V or 1000 V^b Type RHW, RHW-2, and RHH, and 600 V Type RW75, RW90, and R90

(See 4.2.3, Table 36, Table 37, and Table 46, and Annex B)

Size of conductor		Insulation other than composite layers (see Annex G for required or optional overall covering and Table 22 for jacket thickness)	Composite insulation construction Types RHH, RHW, RHW-2, R90, RW75 and RW90							
			Inner layer EP, XL, Silicone, or EPCV			Outer layer CP, CPE, EPCV, or XL				
		mm								
mm ²	AWG or kcmil	Minimum average thickness	Minimum thickness at any point ^a	Minimum average thickness	Minimum thickness at any point ^a		Minimum average thickness	Minimum thickness at any point ^a		
2.08 – 5.26	14 – 10 AWG	1.14	1.02	0.76	A	B	0.38	A	B	
8.37	8	1.52	1.37	1.14	1.02	1.07	0.38	0.36	0.30	
13.3 – 33.6	6 – 2	1.52	1.37	1.14	1.02	1.12	0.76	0.69	0.61	
42.4 – 107	1 – 4/0	2.03	1.83	1.40	1.27	1.37	1.14	1.02	0.91	
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	2.41	2.18	1.65	1.47	1.65	1.65	1.47	1.32	
Larger than 253 – 507	Larger than 500 – 1000	2.79	2.51	2.03	1.83	1.98	1.65	1.47	1.32	
Larger than 507 – 1010	Larger than 1000 – 2000	3.18	2.84	2.54	A	B	2.41	A	B	
mils										
2.08 – 5.26	14 – 10 AWG	45	40	30	A	B		A	B	
8.37	8	60	54	45	27	28	15	14	12	
13.3 – 33.6	6 – 2	60	54	45	40	42	15	14	12	
42.4 – 107	1 – 4/0	60	54	45	40	44	30	27	24	
		80	72	55	50	54	45	40	36	

Table 15 Continued on Next Page

Table 15 Continued

Size of conductor		Insulation other than composite layers (see Annex G for required or optional overall covering and Table 22 for jacket thickness)		Composite insulation construction Types RHH, RHW, RHW-2, R90, RW75 and RW90					
				Inner layer EP, XL, Silicone, or EPCV			Outer layer CP, CPE, EPCV, or XL		
				mm					
mm ²	AWG or kcmil	Minimum average thickness	Minimum thickness at any point ^a	Minimum average thickness	Minimum thickness at any point ^a		Minimum average thickness	Minimum thickness at any point ^a	
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	95	86	65	58	65	65	58	52
Larger than 253 – 507	Larger than 500 – 1000	110	99	80	72	78	65	58	52
Larger than 507 – 1010	Larger than 1000 – 2000	125	112	100	90	99	95	85	76

^a The minimum thickness at any point shall not be less than indicated in Column A or B under inner layer with the minimum thickness at any point not less than indicated in the corresponding Column A or B under outer layer. The thickness in Column B under inner layer plus the thickness in Column B under outer layer equals 90 percent of the sum of the average thickness indicated under inner layer and outer layer.

^b Applies to the United States only.

Table 16
Thicknesses of insulation on 1000 V Types RW75, R90, and RW90

(See 4.2.3 and Annex B)

Size of conductor		Non-composite construction		Composite insulation construction					
				Inner layer: EP, XL, Silicone, or EPCV			Outer layer: CP, CPE, EPCV, or XL		
mm ²		AWG or kcmil		Minimum average thickness	Minimum thickness at any point ^a		Minimum average thickness	Minimum thickness at any point ^a	
–	–	–	–	–	A	B	–	A	B
2.08 – 5.26	14 – 10 AWG	1.14	1.01	0.87	0.78	0.82	0.38	0.36	0.3
8.37	8	1.14	1.01	1.21	1.09	1.15	0.76	0.69	0.61
13.3 – 33.6	6 – 2	1.52	1.37	1.27	1.14	1.22	0.76	0.69	0.61
42.4 – 107	1 – 4/0	2.03	1.82	1.52	1.37	1.47	1.14	1.02	0.91
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	2.28	2.05	1.78	1.60	1.75	1.65	1.47	1.32
Larger than 253 – 507	Larger than 500 – 1000	2.28	2.05	2.16	1.94	2.10	1.65	1.47	1.32
Larger than 507 – 1010	Larger than 1000 – 2000	2.79	2.51	2.67	2.40	2.64	2.41	2.16	1.93
–		–		mils					
–	–	–	–	–	A	B	–	A	B
2.08 – 5.26	14 – 10 AWG	45	40	30	27	28	15	14	12
8.37	8	45	40	30	43	45	30	27	24

Table 16 Continued on Next Page

Table 16 Continued

Size of conductor		Non-composite construction		Composite insulation construction					
				Inner layer: EP, XL, Silicone, or EPCV			Outer layer: CP, CPE, EPCV, or XL		
mm ²	AWG or kcmil	Minimum average thickness	Minimum thickness at any point ^a	Minimum average thickness	Minimum thickness at any point ^a		Minimum average thickness	Minimum thickness at any point ^a	
13.3 – 33.6	6 – 2	60	54	50	45	48	30	27	24
42.4 – 107	1 – 4/0	80	72	60	54	58	45	40	36
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	90	81	70	63	69	65	58	52
Larger than 253 – 507	Larger than 500 – 1000	90	81	85	76	83	65	58	52
Larger than 507 – 1010	Larger than 1000 – 2000	110	99	105	94	104	95	85	76

^a The minimum thickness at any point shall not be less than as indicated in Column A or B under inner layer with the minimum thickness at any point not less than as indicated in the corresponding Column A or B under outer layer. The thickness in Column B under inner layer plus the thickness in Column B under outer layer equals 90 percent of the sum of the average thickness indicated under inner layer and outer layer.

Table 17
Thickness of insulation on 2000 V Types R90, RW75, RW90, RHH, RHW, and RHW-2

(See 4.2.3, Table 36, Table 37, and Table 47, and Annex B)

Size of conductor		EP, XL, Silicone, or EPCV: Types R90, RW75, RW90, RHH, RHW, and RHW-2		CP, CPE, or SBR/IIR/NR Types RHH, RHW, RHW-2		Composite insulation construction Types RHH, RHW, RHW-2, R90, RW75, and RW90						
						Inner layer EP, XL, Silicone, or EPCV			Outer layer CP, CPE, EPCV, or XL			
mm ²	AWG or kcmil	Min. avg. thickness	Min. at any point	Min. avg. thickness	Min. at any point	Min. avg. thickness	Min. thickness at any point ^a		Min. avg. thickness	Min. thickness at any point ^a		
2.08 – 5.26 8.37 13.3 – 33.6 42.4 – 107 Larger than 107 – 253 Larger than 253 – 507 Larger than 507 – 1010	14 – 10 AWG 8 6 – 2 1 – 4/0 Larger than 4/0 – 500 kcmil Larger than 500 – 1000 Larger than 1000 – 2000	mm										
		1.52	1.37	2.03	1.83	1.14	1.02	A	B	0.38	A	B
		1.78	1.60	2.03	1.83	1.40	1.27	1.32	0.76	0.69	0.61	
		1.78	1.60	2.41	2.18	1.40	1.27	1.32	0.76	0.69	0.61	
		2.29	2.06	2.79	2.51	1.65	1.47	1.60	1.14	1.02	0.91	
		2.67	2.39	3.18	2.84	1.90	1.73	1.88	1.65	1.47	1.32	
		3.05	2.74	3.56	3.20	2.29	2.06	2.24	1.65	1.47	1.32	
		3.56	3.20	3.56	3.20	2.92	2.64	2.87	2.41	2.16	1.93	
		mils										
						A	B		A	B		

Table 17 Continued on Next Page

Table 17 Continued

Size of conductor		EP, XL, Silicone, or EPCV: Types R90, RW75, RW90, RHH, RHW, and RHW-2		CP, CPE, or SBR/IIR/NR Types RHH, RHW, RHW-2		Composite insulation construction Types RHH, RHW, RHW-2, R90, RW75, and RW90					
						Inner layer EP, XL, Silicone, or EPCV			Outer layer CP, CPE, EPCV, or XL		
mm ²	AWG or kcmil	Min. avg. thickness	Min. at any point	Min. avg. thickness	Min. at any point	Min. avg. thickness	Min. thickness at any point ^a		Min. avg. thickness	Min. thickness at any point ^a	
2.08 – 5.26	14 – 10 AWG	60	54	80	72	45	40	42	15	14	12
8.37	8	70	63	80	72	55	50	52	30	27	24
13.3 – 33.6	6 – 2	70	63	95	86	55	50	52	30	27	24
42.4 – 107	1 – 4/0	90	81	110	99	65	58	63	45	40	36
mils											
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	105	94	125	112	75	68	74	65	58	52
Larger than 253 – 507	Larger than 500 – 1000	120	108	140	126	90	A 81	B 88	65	A 58	B 52
Larger than 507 – 1010	Larger than 1000 – 2000	140	126	140	126	115	104	113	95	85	76

^a The minimum thickness at any point shall not be less than as indicated in Column A or B under inner layer with the minimum thickness at any point not less than as indicated in the corresponding Column A or B under outer layer. The thickness in Column B under inner layer plus the thickness in Column B under outer layer equals 90 percent of the sum of the average thickness indicated under inner layer and outer layer.

Table 18
Insulation thicknesses on 1000 V Types RWU75 and RWU90

(See 4.2.3 and Annex B)

Conductor size		Insulation thickness			
mm ²	AWG or kcmil	mm		mils	
		Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
2.08 – 5.26	14 – 10 AWG	1.52	1.37	60	54
8.37	8	2.03	1.83	80	72
13.3 – 33.6	6 – 2	2.03	1.83	80	72
42.4 – 107	1 – 4/0	2.41	2.18	95	86
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	2.79	2.51	110	99
Larger than 253 – 507	Larger than 500 – 1000 kcmil	3.18	2.84	125	112
Larger than 507 – 1010	Larger than 1000 – 2000 kcmil	3.56	3.20	140	126

Table 19
Thickness of composite insulations on 1000 V Types RWU75 and RWU90

(See [4.2.3](#))

Size of conductor		Composite construction				Composite construction			
		Inner Layer:		Outer Layer:		Inner Layer:		Outer Layer:	
		XL		CP, CPE, EPCV, or XL		EP, EPCV		CP, CPE, EPCV, or XL	
mm ²	AWG or kcmil	Minimum average thickness	Minimum at any point	Minimum average thickness	Minimum at any point	Minimum average thickness	Minimum at any point	Minimum average thickness	Minimum at any point
mm									
2.08 – 5.26	14 – 10 AWG	1.16	1.04	0.38	0.30	1.16	1.04	1.14	0.91
8.37	8	1.35	1.22	0.76	0.60	1.35	1.22	1.14	0.91
13.3 – 33.6	6 – 2	1.69	1.52	0.76	0.60	1.69	1.52	1.65	1.32
42.4 – 107	1 – 4/0	2.02	1.82	1.14	0.91	2.02	1.82	1.65	1.32
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	2.36	2.12	1.65	1.32	2.36	2.12	2.41	1.93
Larger than 253 – 507	Larger than 500 – 1000	2.87	2.58	1.65	1.32	2.87	2.58	2.41	1.93
Larger than 507 – 1010	Larger than 1000 – 2000	3.55	3.20	2.41	1.93	3.55	3.20	3.17	2.54
mils									
2.08 – 5.26	14 – 10 AWG	45	35	15	12	39	35	45	36
8.37	8	53	48	30	24	53	48	45	36
13.3 – 33.6	6 – 2	67	60	30	24	67	60	65	52
42.4 – 107	1 – 4/0	80	72	45	36	80	72	65	52
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	93	83	65	52	93	83	95	76
Larger than 253 – 507	Larger than 500 – 1000 kcmil	113	102	65	52	113	102	95	76
Larger than 507 – 1010	Larger than 1000 – 2000	140	126	95	76	140	126	125	100

Table 20
Insulations and protective coverings

(See [4.2.1.1](#), [4.3.1](#), [4.9.1.1](#), [Table 37](#), [Table 46](#), [Table 47](#), [G.1.1](#), [G.1.3](#), and Annex B)

Type designation	Insulation	Jacket or fibrous covering	
		Over finished single conductor or single conductor core of a multiconductor cable	Over two or more parallel or twisted conductors
XHH, XHHW, and XHHW-2 SA or SF 2.08 – 8.37 mm ² (14 – 8 AWG)	XL or EPCV Silicone	None One or more glass or aramid braid fibrous coverings	Jacket or fibrous covering ^a Fibrous covering

Table 20 Continued on Next Page

Table 20 Continued

Type designation	Insulation	Jacket or fibrous covering	
SA or SF 13.3 – 1010 mm ² (6 AWG – 2000 kcmil)	Silicone	Two or more glass or aramid braid fibrous coverings	Fibrous covering
SIS	XL, EPCV, CP or CPE	None	Not applicable
RHH, RHW, RHW-2 [600 V or 1000 V ^b , 2.08 – 8.37 mm ² (14 – 8 AWG)]	EP, SBR/IIR, NR	Jacket or one or more fibrous coverings ^a	Jacket or fibrous covering ^a
RHH, RHW, RHW-2 [600 V or 1000 V ^b , 13.3 – 1010 mm ² (6 AWG – 2000 kcmil)] and all 2 kV	EP, SBR/IIR, NR	Jacket or two or more fibrous coverings ^a	Jacket or fibrous covering ^a
RHH, RHW, and RHW-2	XL, EPCV, CP, CPE, Composite	Jacket or fibrous covering ^a (optional)	Jacket or fibrous covering ^a
R90, RW75, RW90	EP	Jacket	Jacket
RWU75, RWU90	EP or EPCV	Jacket	Jacket (optional)
R90, RW75, RW90	XL or EPCV	Jacket (optional)	Jacket
RWU75, RWU90	XL	Jacket (optional)	Jacket (optional)
R90, RW75, RW90	Silicone	Jacket	Jacket
R90, RW75, RW90	Composite	Jacket (optional)	Jacket
RHH, RHW, or RHW-2 (600 V, 1000 V ^b or 2000 V)	Silicone	Jacket or two or more fibrous coverings ^a	Jacket or fibrous covering ^a
^a In the United States, for Types other than SA, the use of a fibrous covering(s) in this table is an alternative to a jacket. ^b Applies to the United States only. In Mexico, for types other than SF, the use of fibrous coverings does not apply. In Canada, the use of fibrous coverings does not apply.			

Table 21
Physical properties of jackets(See [4.3.1](#), [4.9.1.1](#), [4.10.1](#), [4.10.2](#), [5.20](#), [7.2.4](#), and Annex B)

Condition	Test		Material and properties				
			Neoprene, CP, CPE, NBR/PVC		PVC		XL
			75°C	90°C	75°C	90°C	90°C
Before aging	Elongation	Minimum	200 percent	200 percent	100 percent	100 percent	150 percent
	Tensile strength	Minimum	8.3 MPa (1200 lbf/in ²)	8.3 MPa (1200 lbf/in ²)	10.3 MPa (1500 lbf/in ²)	10.3 MPa (1500 lbf/in ²)	10.3 MPa (1500 lbf/in ²)
	Air-oven test	Temperature	100 ±1°C	110 ±1°C	100 ±1°C	121 ±1°C	110 ±1°C
After accelerated aging		Time	10 d	10 d	10 d	7 d	10 d
	Minimum percent of results obtained on	Elongation	50	50	45	45	75
		Tensile strength	50	50	70	85	75

Table 21 Continued on Next Page

Table 21 Continued

Condition	Test		Material and properties			
			Neoprene, CP, CPE, NBR/PVC		PVC	
			75°C	90°C	75°C	90°C
	unaged specimens					
Oil-immersion test (IRM 902)	Temperature		121 ±1°C	121 ±1°C	70 ±1°C	70 ±1°C
	Time		18 h	18 h	4h	4h
	Minimum percent of results obtained on unaged specimens	Elongation	60	60	75	75
		Tensile strength	60	60	75	75

Table 22
Thicknesses of jacket on 600 V, 1000 V, and 2000 V single-conductor Types RW75, RW90, R90, RHW, RHW-2, and RHH

(See 4.3.1, Table 15, and Annex B)

Conductor size		600 V and 1000 V				2000 V			
mm ²	AWG or kcmil	Minimum average jacket thickness	Minimum jacket thickness at any point	Minimum average jacket thickness	Minimum jacket thickness at any point	Minimum average jacket thickness	Minimum jacket thickness at any point	Minimum average jacket thickness	Minimum jacket thickness at any point
		mm	mm	mils	mils	mm	mm	mils	mils
2.08 – 3.31	14 – 12 AWG	0.38	0.30	15	12	0.38	0.30	15	12
5.26	10	0.38	0.30	15	12	0.76	0.61	30	24
8.37 – 26.7	8 – 3	0.76	0.61	30	24	0.76	0.61	30	24
33.6	2	0.76	0.61	30	24	1.14	0.91	45	36
42.4 – 85.0	1 – 3/0	1.14	0.91	45	36	1.14	0.91	45	36
107	4/0	1.14	0.91	45	36	1.65	1.32	65	52
127 – 507	250 – 1000 kcmil	1.65	1.32	65	52	1.65	1.32	65	52
Larger than 507 – 1010	Larger than 1000 – 2000	2.41	1.93	95	76	2.41	1.93	95	76

Table 23
Thicknesses of jacket on 1000 V single-conductor Type RWU75 and RWU90

(See 4.3.1 and Annex B)

Conductor size		Thickness of jacket							
		XL insulated				EP or EPCV insulated			
		Minimum average		Minimum at any point		Minimum average		Minimum at any point	
mm ²	AWG or kcmil	mm	mils	mm	mils	mm	mils	mm	mils
2.08 – 5.26	14 – 10 AWG	0.38	15	0.30	12	1.14	45	0.91	36
8.37	8	0.76	30	0.60	24	1.14	45	0.91	36
13.3 – 26.7	6 – 3	0.76	30	0.60	24	1.65	65	1.32	52
33.6 – 85.0	2 – 3/0	1.14	45	0.91	36	1.65	65	1.32	52
107	4/0	1.65	65	1.32	52	1.65	65	1.32	52
127 – 507	250 – 1000 kcmil	1.65	65	1.32	52	2.41	95	1.93	76
633 – 1010	1250 – 2000	2.41	95	1.93	76	3.17	125	2.54	100

Table 24
Thicknesses of optional jacket on each insulated conductor in 2-conductor flat parallel wire or cable, and on each insulated conductor in a multiple-conductor cable or assembly

(See 4.3.1 and Annex B)

Calculated diameter of insulation under jacket		Thicknesses of jacket ^a			
mm	inch	Average		Minimum at any point	
		mm	mils	mm	mils
0 – 6.35	0 – 0.250	0.38	15	0.30	12
6.36 – 10.80	0.251 – 0.425	0.64	25	0.51	20
10.81 – 17.80	0.426 – 0.700	0.76	30	0.61	24
17.81 – 38.10	0.701 – 1.500	1.27	50	1.02	40
38.11 – 63.50	1.501 – 2.500	2.03	80	1.62	64

^a Not applicable to a colored coating on an insulated conductor.

Table 25
Maximum length of lay of multiple-conductor cables

(See 4.5.1.3)

Number of conductors	Maximum length of lay
2	30 times diameter of finished insulated conductor
3	35 times diameter of finished insulated conductor
4	40 times diameter of finished insulated conductor
5 or more, or assemblies with more than one conductor size	15 times the overall diameter of the assembly, except that in a multiple layer cable, the length of lay of the conductors in any inner layer shall be not more than 20 times the overall diameter of that layer

Table 26
Minimum size of equipment-grounding conductor in multiple-conductor cable Types XHHW-2, XHHW, XHH, RHH, RHW, RHW-2, R90, RW75, RWU75, RWU90, SA, and SF

(See [4.5.2.1](#) and [7.2.2](#))

Circuit conductor size		Size of equipment-grounding conductor							
		75°C (RHW, RW75, RWU75)				90°C (XHHW, XHHW-2, XHH, RHH, RHW-2, R90, RW90, RWU90, SA, SF)			
mm ²	AWG or kcmil	Copper		Aluminum		Copper		Aluminum	
		mm ²	AWG	mm ²	AWG	mm ²	AWG	mm ²	AWG
Copper									
2.08	14 AWG	2.08	14	—	—	2.08	14	—	—
3.31	12	3.31	12			3.31	12		
5.26	10	5.26	10	—	—	5.26	10	—	—
8.37	8	5.26	10	8.37	8	5.26	10	8.37	8
13.3, 21.2	6, 4	8.37	8	13.3	6	8.37	8	13.3	6
26.7	3	8.37	8	13.3	6	13.3	6	21.2	4
33.6 – 67.4	2 – 2/0	13.3	6	21.2	4	13.3	6	21.2	4
85.0	3/0	13.3	6	21.2	4	21.2	4	33.6	2
107 – 152	4/0 – 300 kcmil	21.2	4	33.6	2	21.2	4	33.6	2
177 – 203	350 – 400	26.7	3	42.4	1	26.7	3	42.4	1
253	500	26.7	3	42.4	1	33.6	2	53.5	1/0
304 – 380	600 – 750	33.6	2	53.5	1/0	33.6	2	53.5	1/0
405	800	33.6	2	53.5	1/0	42.4	1	67.4	2/0
456 – 507	900 – 1000	42.4	1	67.4	2/0	42.4	1	67.4	2/0
633	1250	42.4	1	67.4	2/0	53.5	1/0	85.0	3/0
887 – 1010	1500 – 2000	53.5	1/0	85.0	3/0	53.5	1/0	85.0	3/0
Aluminum									
3.31	12 AWG	2.08	14	3.31	12	2.08	14	3.31	12
5.26	10	3.31	12	5.26	10	3.31	12	5.26	10
8.37	8	5.26	10	8.37	8	5.26	10	8.37	8
13.3	6	5.26	10	8.37	8	5.26	10	8.37	8
221.2 – 33.6	4 – 2	8.37	8	13.3	6	8.37	8	13.3	6
42.4	1	8.37	8	13.3	6	13.3	6	21.2	4
53.5 – 85	1/0 – 3/0	13.3	6	21.2	4	13.3	6	21.2	4
107	4/0	13.3	6	21.2	4	21.2	4	33.5	2
126 – 177	250 – 350 kcmil	21.2	4	33.6	2	21.2	4	33.6	2
202	400	21.2	4	33.6	2	26.7	3	42.4	1
253 – 354	500 – 700	26.7	3	42.4	1	26.7	3	42.4	1
380 – 405	750 – 800	26.7	3	42.4	1	33.6	2	53.5	1/0
456 – 507	900 – 1000	33.6	2	53.5	1/0	33.6	2	53.5	1/0
633	1250	33.6	2	53.5	1/0	42.4	1	67.4	2/0
760	1500	42.4	1	67.4	2/0	42.4	1	67.4	2/0
887 – 1010	1750 – 2000	42.4	1	67.4	2/0	53.5	1/0	85.0	3/0

Table 27
Thickness of overall jacket on multiple-conductor cable

(See [4.9.2](#) and Annex [B](#))

Calculated diameter under jacket of round cable or calculated length of major axis under jacket of 2-conductor flat parallel		Thickness of jacket			
mm	inch	Minimum average		Minimum at any point	
		mm	mils	mm	mils
0 – 10.80	0 – 0.425	1.14	45	0.91	36
10.81 – 17.80	0.426 – 0.700	1.52	60	1.22	48
17.81 – 38.10	0.701 – 1.500	2.03	80	1.62	64
38.11 – 63.50	1.501 – 2.500	2.79	110	2.23	88
Over 63.50	Over 2.500	3.55	140	2.85	112

Table 28
Maximum direct-current resistance at 20°C of solid aluminum, bare copper, and coated-copper conductors

(See [5.2.1](#) and [5.2.2](#) and Annex [B](#))

Size of conductor		Aluminum		Bare copper		Coated copper	
mm ²	AWG	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14	—	—	8.45	2.57	8.78	2.68
3.31	12	8.71	2.65	5.31	1.62	5.53	1.68
5.26	10	5.48	1.67	3.34	1.02	3.48	1.06
8.37	8	3.45	1.05	2.10	0.641	2.16	0.659
13.3	6	2.17	0.661	1.32	0.403	1.36	0.415
21.2	4	1.36	0.416	0.832	0.254	0.856	0.261
26.7	3	1.08	0.330	0.660	0.201	0.679	0.207
33.6	2	0.857	0.261	0.523	0.159	0.538	0.164
42.4	1	0.680	0.207	0.415	0.126	0.427	0.130
53.5	1/0	0.539	0.164	0.329	0.100	0.337	0.103
67.4	2/0	0.428	0.130	0.261	0.0795	0.267	0.0814
85.0	3/0	0.339	0.103	0.207	0.0631	0.212	0.0655
107	4/0	0.269	0.0820	0.164	0.0500	0.168	0.0512

Table 29
Maximum direct-current resistance at 20°C of aluminum and bare copper conductors – concentric-stranded Classes B, C, and D; compact-stranded, compressed-stranded, and combination unilay^a

(See [5.2.1](#), [5.2.2](#), and [D.3](#) and Annex [B](#))

Size of conductor		Conductor resistance			
		Aluminum		Bare copper	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	—	—	8.62	2.62
3.31	12	8.88	2.71	5.43	1.65
5.26	10	5.59	1.70	3.41	1.04
8.37	8	3.52	1.07	2.14	0.654
13.3	6	2.21	0.674	1.35	0.411
21.2	4	1.39	0.424	0.848	0.259
26.7	3	1.10	0.336	0.673	0.205
33.6	2	0.875	0.267	0.534	0.163
42.4	1	0.693	0.211	0.423	0.129
53.5	1/0	0.550	0.168	0.335	0.102
67.4	2/0	0.436	0.133	0.266	0.0811
85.0	3/0	0.346	0.106	0.211	0.0643
107	4/0	0.274	0.0836	0.167	0.0510
127	250 kcmil	0.232	0.0708	0.142	0.0432
152	300	0.194	0.0590	0.118	0.0360
177	350	0.166	0.0505	0.101	0.0308
203	400	0.145	0.0442	0.0885	0.0270
228	450	0.129	0.0393	0.0787	0.0240
253	500	0.116	0.0354	0.0709	0.0216
279	550	0.106	0.0322	0.0644	0.0196
304	600	0.0967	0.0295	0.0590	0.0180
329	650	0.0893	0.0272	0.0545	0.0166
355	700	0.0829	0.0253	0.0506	0.0154
380	750	0.0774	0.0236	0.0472	0.0144
405	800	0.0725	0.0221	0.0443	0.0135
456	900	0.0645	0.0197	0.0393	0.0120
507	1000	0.0580	0.0177	0.0354	0.0108
557	1100	0.0528	0.0161	0.0322	0.00981
608	1200	0.0484	0.0147	0.0295	0.00899
633	1250	0.0464	0.0142	0.0283	0.00863
659	1300	0.0447	0.0136	0.0272	0.00823
709	1400	0.0415	0.0126	0.0253	0.00771
760	1500	0.0387	0.0118	0.0236	0.00719
811	1600	0.0363	0.0111	0.0221	0.00674

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Table 29 Continued

Size of conductor		Conductor resistance			
		Aluminum		Bare copper	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
861	1700	0.0341	0.0104	0.0208	0.00635
887	1750	0.0332	0.0101	0.0202	0.00617
912	1800	0.0322	0.00983	0.0197	0.00600
963	1900	0.0306	0.00931	0.0186	0.00568
1010	2000	0.0290	0.00884	0.0177	0.00540

^a Combination unilay strand sizes for copper are 2.08 – 107 mm² (14 – 4/0 AWG), for aluminum 13.3 – 107 mm² (6 – 4/0 AWG).

Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE for copper conductors, and NMX-J-032-ANCE for aluminum conductors.

Table 30
Maximum direct-current resistance at 20°C of copper conductors, concentric-stranded and compressed-stranded Class B, C, and D with each strand coated, and combination unilay^a with each strand coated

(See 5.2.1, 5.2.2, and D.3 and Annex B)

Size of conductor		Class B		Class C and Combination Unilay		Class D	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	8.96	2.73	9.15	2.78	9.25	2.82
3.31	12	5.64	1.72	5.75	1.75	5.75	1.75
5.26	10	3.55	1.08	3.55	1.08	3.62	1.10
8.37	8	2.23	0.679	2.23	0.679	2.23	0.679
13.3	6	1.40	0.427	1.41	0.427	1.41	0.427
21.2	4	0.882	0.269	0.882	0.269	0.882	0.269
26.7	3	0.700	0.213	0.700	0.213	0.700	0.213
33.6	2	0.555	0.169	0.555	0.169	0.555	0.169
42.4	1	0.440	0.134	0.440	0.134	0.440	0.134
53.5	1/0	0.349	0.106	0.349	0.106	0.349	0.106
67.4	2/0	0.276	0.0843	0.276	0.0844	0.276	0.0844
85.0	3/0	0.219	0.0669	0.219	0.0669	0.219	0.0669
107	4/0	0.172	0.0525	0.174	0.0530	0.174	0.0530
127	250 kcmil	0.147	0.0449	0.147	0.0449	0.147	0.0449
152	300	0.122	0.0374	0.122	0.0374	0.122	0.0374
177	350	0.105	0.0320	0.105	0.0320	0.105	0.0320
203	400	0.0911	0.0278	0.0920	0.0280	0.0920	0.0280
228	450	0.0810	0.0247	0.0818	0.0248	0.0818	0.0249
253	500	0.0729	0.0222	0.0736	0.0224	0.0736	0.0224
279	550	0.0669	0.0204	0.0669	0.0204	0.0669	0.0204

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Table 30 Continued

Size of conductor		Class B		Class C and Combination Unilay		Class D	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
304	600	0.0614	0.0187	0.0614	0.0187	0.0614	0.0187
329	650	0.0561	0.0171	0.0566	0.0172	0.0566	0.0172
355	700	0.0520	0.0159	0.0526	0.0160	0.0526	0.0160
380	750	0.0486	0.0148	0.0491	0.0150	0.0491	0.0150
405	800	0.0455	0.0139	0.0460	0.0141	0.0460	0.0141
456	900	0.0405	0.0123	0.0409	0.0124	0.0409	0.0124
507	1000	0.0364	0.0111	0.0364	0.0111	0.0368	0.0112
557	1100	0.0331	0.0101	0.0335	0.0102	0.0335	0.0102
608	1200	0.0303	0.00925	0.0307	0.00935	0.0307	0.00935
633	1250	0.0292	0.00888	0.0295	0.00898	0.0295	0.00898
659	1300	0.0280	0.00854	0.0284	0.00863	0.0284	0.00863
709	1400	0.0260	0.00793	0.0260	0.00794	0.0263	0.00802
760	1500	0.0243	0.00740	0.0243	0.00741	0.0246	0.00748
811	1600	0.0228	0.00694	0.0231	0.00702	0.0231	0.00702
861	1700	0.0214	0.00653	0.0216	0.00660	0.0216	0.00660
887	1750	0.0208	0.00635	0.0210	0.00642	0.0210	0.00642
912	1800	0.0202	0.00617	0.0202	0.00617	0.0205	0.00623
963	1900	0.0192	0.00584	0.0192	0.00584	0.0194	0.00591
1010	2000	0.0182	0.00555	0.0183	0.00555	0.0184	0.00561

^a Combination unilay strand sizes are 2.08 – 107 mm² (14 – 4/0 AWG).

Note: Nominal strand configuration and number of wires are found in ASTM B8 or NMX-J-012-ANCE.

Table 31
Maximum direct-current resistance at 20°C of Class G and H stranded conductors

(See 5.2.1 and 5.2.2, and Annex B)

Size of conductor		Bare copper				Coated copper ^a				Aluminum			
		Class G		Class H		Class G		Class H		Class G		Class H	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
	AWG												
2.08	14	8.70	2.65	—	—	9.24	2.82	—	—	—	—	—	—
3.31	12	5.48	1.67	—	—	5.81	1.77	—	—	—	—	—	—
5.26	10	3.45	1.05	—	—	3.66	1.11	—	—	—	—	—	—
8.37	8	2.16	0.660	2.18	0.666	2.30	0.701	—	—	—	—	—	—
13.3	6	1.37	0.415	1.38	0.419	1.42	0.431	—	—	2.23	0.680	—	—
21.2	4	0.857	0.261	0.865	0.263	0.890	0.271	—	—	1.41	0.428	—	—
26.7	3	0.679	0.207	0.6866	0.209	0.707	0.215	—	—	1.11	0.340	—	—

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Table 31 Continued

Size of conductor		Bare copper				Coated copper ^a				Aluminum			
		Class G		Class H		Class G		Class H		Class G		Class H	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
33.6	2	0.539	0.164			0.560	0.170			0.883	0.369	—	—
(No. of wires)		Class H only											
33.6	2 (133)			0.544	0.166			0.566	0.172			0.891	0.271
33.6	2 (259)			0.547	0.166			0.580	0.176			—	—
42.4	1	0.431	0.132	0.434	0.133	0.449	0.137	—	—	0.707	0.215	—	—
53.5	1/0	0.342	0.104	0.344	0.105	0.355	0.108	—	—	0.560	0.170	—	—
67.4	2/0	0.271	0.0826	0.272	0.0830	0.282	0.0860	—	—	0.445	0.136	—	—
85.0	3/0	0.215	0.0656			0.223	0.0681			0.353	0.107		
(No. of wires)		Class H only											
85.0	3/0 (259)			0.216	0.0659			0.224	0.0685			0.354	0.108
85.0	3/0 (427)			0.217	0.0662			0.231	0.0703			—	—
107	4/0 (259)			0.171	0.0522			0.179	0.0544			0.280	0.0857
107	4/0 (427)			0.172	0.0525			0.180	0.0546			0.283	0.0861
107	4/0 kcmil	0.170	0.0520			0.177	0.0541			0.279	0.0853		
127	250	0.145	0.0443	0.146	0.0445	0.151	0.0460	0.152	0.0462	0.238	0.0725	0.239	0.0728
152	300	0.121	0.0368	0.121	0.0370	0.125	0.0384	0.126	0.0386	0.198	0.0604	0.199	0.0607
177	350	0.104	0.0316	0.104	0.0317	0.108	0.0328	0.108	0.0330	0.170	0.0518	0.170	0.0520
203	400	0.0917	0.0276	0.0911	0.0277	0.0942	0.0288	0.0948	0.0289	0.149	0.0453	0.149	0.0455
226	450	0.0806	0.0246	0.0810	0.0247	0.0838	0.0255	0.0843	0.0257	0.132	0.0403	0.133	0.0405
253	500	0.0725	0.0221	0.0729	0.0222	0.0755	0.0230	0.0758	0.0232	0.119	0.0362	0.119	0.0364
279	550	0.0663	0.0202	0.0669	0.0204	0.0690	0.0210	0.0696	0.0212	0.108	0.0332	0.110	0.0335
304	600	0.0607	0.0186	0.0613	0.0187	0.0631	0.0193	0.0638	0.0195	0.0996	0.0304	0.100	0.0306
329	650	0.0561	0.0171	0.0566	0.0172	0.0583	0.0177	0.0589	0.0180	0.0919	0.0280	0.0928	0.0283
355	700	0.0520	0.0159	0.0525	0.0160	0.0542	0.0165	0.0547	0.0166	0.0834	0.0260	0.0862	0.0262
380	750	0.0486	0.0148	0.0491	0.0150	0.0505	0.0154	0.0510	0.0155	0.0797	0.0243	0.0804	0.0245
405	800	0.0456	0.0139	0.0460	0.0140	0.0473	0.0145	0.0478	0.0146	0.0747	0.0227	0.0754	0.0230
456	900	0.0405	0.0123	0.0409	0.0124	0.0421	0.0129	0.0425	0.0130	0.0664	0.0202	0.0670	0.0204
507	1000	0.0364	0.0111	0.0368	0.0112	0.0379	0.0115	0.0382	0.0116	0.0598	0.0183	0.0603	0.0184
608	1200	.0304	.00926	.0307	.00934	0.0316	0.00963	0.0319	0.00972	0.0498	0.0152	0.0503	0.0153
633	1250	0.0292	0.00888	0.0295	0.00897	0.0303	0.00924	0.0306	0.00933	0.0478	0.0146	0.0482	0.0147
659	1300	0.0280	0.00855	0.0283	0.00863	0.0292	0.00888	0.0295	0.00897	0.0460	0.0140	0.0464	0.0142
709	1400	0.0260	0.00794	0.0263	0.00801	0.0270	0.00825	0.0273	0.00833	0.0426	0.0131	0.0430	0.0132
760	1500	0.0243	0.00741	0.0245	0.00748	0.0253	0.00770	0.0255	0.00777	0.0398	0.0121	0.0402	0.0122
811	1600	0.0230	0.00701	0.0230	0.00701	0.0239	0.00729	0.0239	0.00729	0.0377	0.0115	0.0377	0.0115
861	1700	0.0216	0.00660	0.0216	0.00660	0.0225	0.00686	0.0225	0.00686	0.0355	0.0108	0.0355	0.0108

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Table 31 Continued

Size of conductor		Bare copper				Coated copper ^a				Aluminum			
		Class G		Class H		Class G		Class H		Class G		Class H	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
887	1750	0.0210	0.00641	0.0210	0.00641	0.0218	0.00666	0.0218	0.00666	0.0345	0.0105	0.0345	0.0105
912	1800	0.0204	0.00623	0.0204	0.00623	0.0212	0.00648	0.0212	0.00648	0.0335	0.0102	0.0335	0.0102
963	1900	0.0194	0.00591	0.0194	0.00591	0.0201	0.00614	0.0201	0.00614	0.0317	0.00968	0.0317	0.00968
1010	2000	0.0184	0.00561	0.0184	0.00561	0.0192	0.00583	0.0192	0.00583	0.0302	0.00919	0.0302	0.00919

^a Each strand coated with tin.**Note:** Nominal strand configuration and number of wires are found in ASTM B173 or NMX-J-013-ANCE.

Table 32
Maximum direct-current resistance at 20°C of Class M stranded conductors

(See 5.2.1 and 5.2.2 and Annex B)

Size of conductor		Bare copper		Coated copper (each strand coated with tin)	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
2.08	14 AWG	8.61	2.62	9.25	2.82
3.31	12	5.53	1.68	5.94	1.81
5.26	10	3.48	1.06	3.73	1.14
8.37	8	2.18	0.666	2.35	0.715
13.3	6	1.39	0.423	1.49	0.455
21.2	4	0.873	0.266	0.937	0.286
26.7	3	0.699	0.213	0.744	0.226
33.6	2	0.554	0.169	0.595	0.182
42.4	1	0.440	0.134	0.472	0.144
53.5	1/0	0.349	0.106	0.374	0.114
67.4	2/0	0.276	0.0851	0.300	0.0913
85.0	3/0	0.221	0.0874	0.238	0.0724
107	4/0	0.175	0.0534	0.189	0.0574
127	250 kcmil	0.149	0.0453	0.159	0.0487
152	300	0.123	0.0377	0.133	0.0405
177	350	0.106	0.0323	0.114	0.0347
203	400	0.0928	0.0283	0.0997	0.0304
226	450	0.0825	0.0252	0.0858	0.0261
253	500	0.0743	0.0226	0.0798	0.0243
279	550	0.0675	0.0206	0.0725	0.0221
304	600	0.0619	0.0189	0.0664	0.0203
329	650	0.0571	0.0174	0.0613	0.0187
355	700	0.0530	0.0162	0.0569	0.0173
380	750	0.0495	0.0151	0.0531	0.0162
405	800	0.0464	0.0142	0.0499	0.0152
456	900	0.0413	0.0125	0.0443	0.0135
507	1000	0.0371	0.0113	0.0399	0.0121

Note: Nominal strand configuration and number of wires are found in ASTM B172 or NMX-J-014-ANCE.

Table 33
Maximum direct-current resistance at 20°C of Class I and K stranded conductors

(See [5.2.1](#), [5.2.2](#) and Annex B)

Size of conductor		Class I						Class K			
		Bare copper		Coated copper		Aluminum		Bare copper		Coated copper	
mm ²	AWG or kcmil	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft	Ohms per km	Ohms per 1000 ft
	AWG										
2.08	14	—	—	—	—	—	—	8.61	2.62	9.25	2.82
3.31	12	—	—	—	—	—	—	5.43	1.65	5.82	1.77
5.26	10	3.41	1.04	3.55	1.08	—	—	3.41	1.04	3.66	1.11
8.37	8	2.14	0.654	2.23	0.679	3.52	1.07	2.18	0.666	2.35	0.715
13.3	6	1.38	0.419	1.43	0.436	2.25	0.687	1.38	0.419	1.48	0.450
21.2	4	0.865	0.263	0.900	0.274	1.42	0.432	0.865	0.263	0.928	0.283
26.7	3	0.686	0.209	0.713	0.217	1.12	0.343	0.693	0.211	0.744	0.226
33.6	2	0.544	0.166	0.566	0.172	0.891	0.271	0.549	0.167	0.590	0.180
42.4	1	0.431	0.132	0.449	0.137	0.707	0.215	0.436	0.133	0.467	0.143
53.5	1/0	0.345	0.105	0.359	0.109	0.566	0.172	0.345	0.105	0.370	0.113
67.4	2/0	0.273	0.0834	0.285	0.0868	0.449	0.137	0.276	0.0843	0.297	0.0904
85.0	3/0	0.217	0.0662	0.225	0.0689	0.356	0.108	0.219	0.0668	0.236	0.0717
107	4/0	0.172	0.0525	0.180	0.0546	0.283	0.0861	0.173	0.0530	0.187	0.0569
	kcmil										
127	250	0.147	0.0449	0.153	0.0466	0.242	0.0735	0.147	0.0449	0.158	0.0481
152	300	0.122	0.0373	0.128	0.0389	0.201	0.0613	0.122	0.0373	0.132	0.0401
177	350	0.105	0.0320	0.109	0.0334	0.172	0.0525	0.106	0.0323	0.114	0.0347
203	400	0.0920	0.0280	0.0957	0.0292	0.151	0.0460	0.092	0.0283	0.0997	0.0304
226	450	0.0817	0.0249	0.0850	0.0259	0.134	0.0408	0.082	0.0252	0.0886	0.0270
253	500	0.0735	0.0224	0.0765	0.0234	0.120	0.0367	0.074	0.0226	0.0798	0.0243
279	550	0.0669	0.0204	0.0696	0.0212	0.110	0.0335	0.067	0.0206	0.0725	0.0221
304	600	0.0613	0.0187	0.0638	0.0195	0.100	0.0306	0.061	0.0189	0.0664	0.0203
329	650	0.0571	0.0174	0.0594	0.0182	0.0936	0.0286	0.057	0.0174	0.0613	0.0187
355	700	0.0530	0.0162	0.0552	0.0168	0.0870	0.0265	0.053	0.0162	0.0569	0.0173
380	750	0.0495	0.0151	0.0515	0.0157	0.0812	0.0248	0.049	0.0151	0.0531	0.0162
405	800	0.0464	0.0142	0.0482	0.0147	0.0761	0.0232	0.046	0.0142	0.0499	0.0152
456	900	0.0413	0.0125	0.0429	0.0131	0.0676	0.0206	0.041	0.0125	0.0443	0.0135
507	1000	0.0371	0.0113	0.0387	0.0117	0.0610	0.0186	0.037	0.0113	0.0399	0.0121
557	1100	0.0338	0.0103	0.0351	0.0107	0.0554	0.0168	—	—	—	—
608	1200	0.0310	0.00944	0.0322	0.00981	0.0507	0.0155	—	—	—	—
633	1250	0.0297	0.00906	0.0310	0.00941	0.0487	0.0149	—	—	—	—
659	1300	0.0286	0.00871	0.0297	0.00906	0.0468	0.0143	—	—	—	—
709	1400	0.0265	0.00809	0.0275	0.00840	0.0435	0.0133	—	—	—	—
760	1500	0.0248	0.00755	0.0257	0.00784	0.0406	0.0123	—	—	—	—
811	1600	0.0233	0.00708	0.0242	0.00735	0.0380	0.0116	—	—	—	—
861	1700	0.0218	0.00666	0.0227	0.00693	0.0358	0.0109	—	—	—	—
887	1750	0.0212	0.00647	0.0220	0.00672	0.0348	0.0106	—	—	—	—
912	1800	0.0206	0.00629	0.0214	0.00654	0.0339	0.0103	—	—	—	—
963	1900	0.0196	0.00596	0.0203	0.00619	0.0320	0.00977	—	—	—	—
1010	2000	0.0186	0.00566	0.0193	0.00589	0.0304	0.00928	—	—	—	—

Table 34
Minimum long-term insulation resistance at rated temperatures – Types RW75 and RW90 with XL insulation and XL composite insulation

(See 5.4.1.1, 5.4.1.2, Table 36, and Annex B)

Conductor size		Minimum IR at 75°C for RW75						Minimum IR at 90°C for RW90					
		600 V		1000 V		2000 V		600 V		1000 V		2000 V	
mm²	AWG or kcmil	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft
	AWG												
2.08	14	15.5	50.9	21.0	68.9	25.4	83.3	11.5	37.7	15.5	50.9	19.1	62.5
3.31	12	13.0	42.7	17.5	57.4	21.8	71.6	9.8	32.2	13.0	42.7	16.4	53.7
5.26	10	10.5	34.4	14.5	47.6	18.5	60.7	8.1	26.6	11.0	36.1	13.9	45.5
8.37	8	12.5	41.0	12.0	39.4	17.5	57.5	9.4	30.8	9.3	30.5	13.1	43.1
13.3	6	10.0	32.8	13.0	42.7	14.7	48.4	7.8	25.6	9.7	31.8	11.1	36.3
21.2	4	8.5	27.9	10.5	34.4	12.3	40.4	6.4	21.0	8.1	26.6	9.2	30.3
26.7	3	7.7	25.3	9.8	32.2	11.2	36.8	5.8	19.0	7.4	24.3	8.4	27.6
33.6	2	7.0	23.0	8.9	29.2	10.2	33.5	5.2	17.1	6.7	22.0	7.7	25.1
42.4	1	7.5	24.6	10.0	32.8	11.3	37.0	5.6	18.4	7.6	24.9	8.5	27.8
53.5	1/0	6.8	22.3	9.2	30.2	10.3	33.7	5.1	16.7	6.9	22.6	7.7	25.3
67.4	2/0	8.4	27.6	8.4	27.6	9.3	30.6	4.6	15.1	6.3	20.7	7.0	23.0
85.0	3/0	7.6	24.9	7.6	24.9	8.4	27.7	4.1	13.5	5.7	18.7	6.3	20.8
107	4/0	4.9	16.1	6.8	22.3	7.6	25.1	3.7	12.1	5.1	16.7	5.7	18.8
	kcmil												
127	250	5.3	17.4	7.0	23.0	8.1	26.6	4.0	13.1	5.3	17.4	6.1	20.0
152	300	4.9	16.1	6.5	21.3	7.5	24.6	3.7	12.1	4.9	16.1	5.6	18.4
177	350	4.6	15.1	6.0	19.7	7.0	23.0	3.4	11.2	4.5	14.8	5.3	17.2
203	400	4.3	14.1	5.7	18.7	6.6	21.7	3.2	10.5	4.3	14.1	5.0	16.3
253	500	3.9	12.8	5.1	16.7	6.0	19.6	2.9	9.5	3.8	12.5	4.5	14.7
304	600	4.3	14.1	4.7	15.4	6.2	20.4	3.2	10.5	3.5	11.5	4.7	15.3
355	700	4.0	13.1	4.4	14.4	5.8	19.0	3.0	9.8	3.3	10.8	4.3	14.3
380	750	3.9	12.8	4.3	14.1	5.6	18.4	2.9	9.5	3.2	10.5	4.2	13.8
405	800	3.8	12.5	4.1	13.5	5.5	17.9	2.8	9.2	3.1	10.2	4.1	13.4
456	900	3.6	11.8	3.9	12.8	5.2	17.0	2.7	8.9	2.9	9.5	3.9	12.7
507	1000	3.4	11.2	3.7	12.1	4.9	16.2	2.5	8.2	2.8	9.2	3.7	12.1
608	1250	3.6	11.8	4.1	13.5	5.1	16.8	2.7	8.9	3.0	9.8	3.8	12.6
760	1500	3.3	10.8	3.7	12.1	4.7	15.5	2.5	8.2	2.8	9.2	3.5	11.6
887	1750	3.1	10.2	3.5	11.5	4.4	14.4	2.3	7.5	2.6	8.5	3.3	10.8
1010	2000	2.9	9.5	3.2	10.5	4.1	13.5	2.2	7.2	2.4	7.9	3.1	10.2

Note:

K = 60 at 75°C for GΩ·m and 196 for MΩ·1000 ft.

K = 45 at 90°C for GΩ·m and 148 for MΩ·1000 ft.

Table 35
Minimum long-term insulation resistance at rated temperatures – 1000 V Types RWU75 and RWU90

(See [5.4.1.1](#), [5.4.1.2](#), and Annex B)

Conductor size		Minimum IR at 75°C for RWU75		Minimum IR at 90°C for RWU90	
mm ²	AWG or kcmil	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft
2.08	14 AWG	25.0	82.0	19.0	62.3
3.31	12	21.0	68.9	16.0	52.5
5.26	10	18.0	59.1	13.5	44.3
8.37	8	19.0	62.3	14.0	45.9
13.3	6	16.0	52.5	12.0	39.4
21.2	4	13.5	44.3	10.0	32.8
26.7	3	12.0	39.4	9.3	30.5
33.6	2	11.0	36.1	8.5	27.9
42.4	1	11.5	37.7	8.8	28.9
53.5	1/0	10.5	34.4	8.0	26.2
67.4	2/0	9.7	31.8	7.3	24.0
85.0	3/9	8.8	28.9	6.6	21.7
107	4/0	8.0	26.2	6.0	19.7
127	250 kcmil	8.4	27.6	6.3	20.7
152	300	7.7	25.3	5.8	19.0
177	350	7.2	23.6	5.4	17.7
203	400	6.8	22.3	5.1	16.7
253	500	6.2	20.3	4.6	15.1
304	600	6.4	21.0	4.8	15.7
355	700	5.9	19.4	4.4	14.4
380	750	5.8	19.0	4.3	14.1
405	800	5.6	18.4	4.2	13.8
456	900	5.3	17.4	4.0	13.1
507	1000	5.1	16.7	3.8	12.5
608	1250	5.1	16.7	3.8	12.5
760	1500	4.7	15.4	3.5	11.5
887	1750	4.3	14.1	3.2	10.5
1010	2000	4.1	13.5	3.0	9.8

Note:

K = 60 at 75°C for GΩ·m and 196 for MΩ·1000 ft.

K = 45 at 90°C for GΩ·m and 148 for MΩ·1000 ft.

Table 36
Minimum long-term insulation resistance at rated temperature – Types XHHW, XHHW-2, RHW, RHW-2, non-XL RW75, and RW90

(See [5.4.1.1](#), [5.4.1.2](#), and Annex [B](#))

Conductor size		Type XHHW-2 and XHHW with insulation thickness as indicated in Table 12	Minimum long-term insulation resistance at rated temperature ^a					
			600 V or 1000 V ^d Types RHW-2, RHW, and 600 V RW75 ^{b,c} and RW90 ^{b,c} with insulation thickness in accordance with Table 15			2000 V Types RHW-2, RHW, RW75 ^{b,c} and RW90 ^{b,c} with insulation thickness in accordance with Table 17		
			CP, CPE, SBR/IIR, and silicone or silicone composite	EP, EPCV, XL	Composite EP, XL, or EPCV inner with EPCV, XL, CP, or CPE outer	CP, CPE, SBR/IIR, and silicone or silicone composite	EP, EPCV, XL	Composite EP, XL, or EPCV inner with EPCV, XL, CP, or CPE outer
mm ²	AWG		GΩ·m					
2.08	14	0.060	0.030	0.075	0.075	0.045	0.090	0.090
3.31	12	0.050	0.025	0.065	0.065	0.040	0.080	0.080
5.26	10	0.040	0.025	0.055	0.055	0.035	0.070	0.070
8.37	8	0.045	0.020	0.055	0.055	0.025	0.060	0.065
13.3	6	0.035	0.020	0.045	0.055	0.025	0.050	0.055
21.2	4	0.030	0.015	0.035	0.045	0.020	0.040	0.050
26.7	3	0.025	0.015	0.035	0.040	0.020	0.040	0.045
33.6	2	0.025	0.015	0.030	0.035	0.020	0.035	0.040
42.4	1	0.025	0.015	0.035	0.040	0.020	0.040	0.045
53.5	1/0	0.025	0.015	0.030	0.040	0.020	0.035	0.045
67.4	2/0	0.020	0.015	0.030	0.035	0.015	0.030	0.040
85.0	3/0	0.020	0.010	0.025	0.030	0.015	0.030	0.035
107	4/0	0.020	0.010	0.025	0.030	0.015	0.025	0.030
mm ²	AWG		MΩ·1000ft					
2.08	14	0.180	0.095	0.240	0.240	0.135	0.290	0.290
3.31	12	0.155	0.080	0.205	0.205	0.120	0.250	0.250
5.26	10	0.125	0.070	0.175	0.175	0.105	0.215	0.215
8.37	8	0.130	0.065	0.165	0.165	0.080	0.185	0.210
13.3	6	0.110	0.055	0.135	0.165	0.075	0.155	0.180
21.2	4	0.090	0.045	0.115	0.135	0.065	0.130	0.150
26.7	3	0.080	0.040	0.105	0.125	0.060	0.115	0.135
33.6	2	0.075	0.035	0.095	0.110	0.055	0.105	0.125
42.4	1	0.075	0.040	0.105	0.130	0.055	0.115	0.140
53.5	1/0	0.070	0.040	0.100	0.115	0.050	0.105	0.125
67.4	2/0	0.060	0.035	0.085	0.105	0.045	0.095	0.115
85.0	3/0	0.055	0.030	0.080	0.095	0.040	0.085	0.105
107	4/0	0.050	0.025	0.070	0.090	0.035	0.080	0.095

^a Types XHHW-2 and RHW-2 are tested at 90°C; Types XHHW and RHW are tested at 75°C.

^b Type RW75 and RW90 XL and XL composites – See [Table 34](#)

^c Type RW75 and RW90 rated 1000 V – See [Table 16](#)

^d Applies to the United States only.

Table 37
Minimum long-term insulation resistance at 97°C – Types XHH, RHH, and silicone or silicone composite R90^a

(See 5.5.2.1, 5.5.2.3, and Annex B)

Conductor size		Type XHH with insulation thickness in accordance with Table 12	600 V or 1000 V ^b Type RHH or 600 V Type R90 ^a with insulation thickness in accordance with Table 15				2000 V Type RHH or R90 with insulation thickness in accordance with Table 17		
			CP, CPE, SBR/IIR, silicone, or silicone composite	EP, EPCV, XL	Composite EP, XL, or EPCV inner with EPCV, XL, CP, or CPE outer	Composite EP, XL, or EPCV inner with EPCV, XL, CP, or CPE outer	CP, CPE, SBR/IIR, silicone, or silicone composite	EP, EPCV, XL	Composite EP, XL, or EPCV inner with EPCV, XL, CP, or CPE outer
mm ²	AWG	GΩ·m							
2.08	14	0.060	0.030	0.075	0.075	0.045	0.090	0.090	
3.31	12	0.050	0.025	0.065	0.065	0.040	0.080	0.080	
5.26	10	0.040	0.025	0.055	0.055	0.035	0.070	0.070	
8.37	8	0.045	0.020	0.055	0.055	0.025	0.060	0.065	
13.3	6	0.035	0.020	0.045	0.055	0.025	0.050	0.055	
21.2	4	0.030	0.015	0.035	0.045	0.020	0.040	0.050	
26.7	3	0.025	0.015	0.035	0.040	0.020	0.040	0.045	
33.6	2	0.025	0.015	0.030	0.035	0.020	0.035	0.040	
42.4	1	0.025	0.015	0.035	0.040	0.020	0.040	0.045	
53.5	1/0	0.025	0.015	0.030	0.040	0.020	0.035	0.045	
67.4	2/0	0.020	0.015	0.030	0.035	0.015	0.030	0.040	
85.0	3/0	0.020	0.010	0.025	0.030	0.015	0.030	0.035	
107	4/0	0.020	0.010	0.025	0.030	0.015	0.025	0.030	
mm ²	AWG	MΩ·1000 ft							
2.08	14	0.180	0.095	0.240	0.240	0.135	0.290	0.290	
3.31	12	0.155	0.080	0.205	0.205	0.120	0.250	0.250	
5.26	10	0.125	0.070	0.175	0.175	0.105	0.215	0.215	
8.37	8	0.130	0.065	0.165	0.165	0.080	0.185	0.210	
13.3	6	0.110	0.055	0.135	0.165	0.075	0.155	0.180	
21.2	4	0.090	0.045	0.115	0.135	0.065	0.130	0.150	
26.7	3	0.080	0.040	0.105	0.125	0.060	0.115	0.135	
33.6	2	0.075	0.035	0.095	0.110	0.055	0.105	0.125	
42.4	1	0.075	0.040	0.105	0.130	0.055	0.115	0.140	
53.5	1/0	0.070	0.040	0.100	0.115	0.050	0.105	0.125	
67.4	2/0	0.060	0.035	0.085	0.105	0.045	0.095	0.115	
85.0	3/0	0.055	0.030	0.080	0.095	0.040	0.085	0.105	
107	4/0	0.050	0.025	0.070	0.090	0.035	0.080	0.095	

^a See Table 20 for acceptable insulation.

^b Applies to the United States only.

Table 38
Minimum long-term insulation resistance at 97°C – Type R90 employing all materials except silicone

(See [5.5.2.1](#), [5.5.2.3](#), and Annex B)

Conductor size		Minimum IR at 97°C					
mm ²	AWG or kcmil	600 V		1000 V		2000 V	
		GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft
2.08	14 AWG	3.54	11.61	4.77	15.65	5.72	18.77
3.31	12	2.98	9.78	4.04	13.25	4.93	16.17
5.26	10	2.46	8.07	3.38	11.08	4.18	13.71
8.37	8	2.84	9.32	2.84	9.32	3.96	13.35
13.3	6	2.36	7.74	2.98	9.78	3.35	11.00
21.2	4	1.94	6.36	2.47	8.10	2.79	9.15
26.7	3	1.76	5.77	2.40	7.88	2.55	8.37
33.6	2	1.59	5.21	2.04	6.69	2.32	7.61
42.4	1	1.70	5.58	2.33	7.64	2.56	8.40
53.5	1/0	1.53	5.02	2.11	6.92	2.33	7.64
67.4	2/0	1.39	4.58	1.92	6.30	2.12	6.96
85.0	3/0	1.24	4.07	1.74	5.71	1.92	6.30
107	4/0	1.12	3.67	1.57	5.15	1.74	5.71
127	250 kcmil	1.21	3.97	1.62	5.31	1.85	6.07
152	300	1.11	3.64	1.49	4.89	1.71	5.61
177	350	1.04	3.41	1.39	4.56	1.59	5.21
203	400	0.88	2.89	1.31	4.30	1.50	4.92
253	500	0.91	2.99	1.19	3.90	1.36	4.46
304	600	0.88	2.89	1.09	3.58	1.41	4.62
355	700	0.91	2.99	1.02	3.35	1.32	4.30
380	750	0.88	2.89	0.99	3.25	1.28	4.20
405	800	0.86	2.82	0.97	3.18	1.24	4.07
456	900	0.81	2.66	0.91	2.99	1.18	3.87
507	1000	0.77	2.53	0.86	2.82	1.12	3.67
608	1250	0.82	2.69	0.94	3.08	–	–
760	1500	0.75	2.46	0.86	2.82	–	–
887	1750	0.70	2.30	0.80	2.62	–	–
1010	2000	0.65	2.13	0.75	2.46	–	–

Note: K = 13.3 for GΩ·m and 43.6 for MΩ·1000 ft.

Table 39
Mandrel diameters for heat shock test^a

(See [5.9](#))

Overall diameter of wire		Number of adjacent turns	Diameter of mandrel as a multiple of the overall wire or cable diameter
mm	inch		
0 – 19.0	0 – 0.75	6	3
19.1 – 38.1	0.76 – 1.5	180° bend	8
Over 38.1	Over – 1.5	180° bend	12

^a Maximum mandrel diameter based on the calculated insulation diameter. For convenience, a mandrel of smaller diameter may be used to represent the specified size. In the case of non-conformance, the specified mandrel shall be used.

Table 40
Mandrel diameters for cold bend test – single conductors^a

(See [5.11.1](#), [G.8.2](#), and [G.8.4](#))

Conductor size mm ²	AWG/kcmil	Bend method	Mandrel diameter	
			600 – 2000 V	5000 V
2.08 – 33.6	14 – 2	6 adjacent turns	5 x outside diameter	8 x outside diameter
42.4 – 253	1 – 500	180° bend	7 x outside diameter	10 x outside diameter
Larger than 253	Larger than 500 kcmil	180° bend	10 x outside diameter	12 x outside diameter

^a When the mandrel specified is not available, a mandrel with a smaller diameter may be used. However, in the case of noncompliant results, the wire or cable shall be retested using the specified mandrel.

Table 41
Mandrel diameters for cold bend test – multiple-conductor cables^a

(See [5.11.1](#))

Cable configuration	Mandrel diameter	Number of turns
2-conductor, parallel	6 times overall minor cross-sectional axis	1/2 (180° bend)
Multiple-conductor, twisted	8 times overall diameter	1/2 (180° bend)

^a When the mandrel specified is not available, a mandrel with a smaller diameter may be used. However, in the case of noncompliant results, the wire or cable shall be retested using the specified mandrel.

Table 42
Deformation load requirements

(See [5.12.1](#))

Size of conductor		Load ^a exerted on a specimen by the foot of the rod	
mm ²	AWG or kcmil	N	gf
2.08 – 8.37	14 – 8 AWG	4.90	500
13.3 – 42.4	6 – 1	7.35	750
53.5 – 107	1/0 – 4/0	9.81	1000
127 – 1010	250 – 2000 kcmil	19.61	2000

^a The specified load is not the weight to be added to each rod in the test apparatus but rather the total of the weight added and the weight of the rod. Because the weight of the rod varies from one apparatus to another, specifying the exact weight to be added to a rod to achieve the specified load on a specimen in all cases is impractical except for an individual apparatus.

Table 43
Test potential for spark test

(See 5.23.2 and 7.4.1, and Annex B)

Conductor size		RMS test potential in kV	
mm ²	AWG or kcmil	600 V	1000 V or 2000 V
2.08 – 5.26	14 – 10 AWG	7.5	10.0
8.37 – 33.6	8 – 2	10.0	12.5
42.4 – 107	1 – 4/0	12.5	15.0
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	15.0	17.5
Larger than 253 – 507	Larger than 500 – 1000	17.5	20.0
Larger than 507 – 1010	Larger than 1000 – 2000	20.0	22.5

Table 44
AC test voltages for dielectric strength test

(See 5.24.1 and Annex B)

Conductor size		One minute test voltage, kV	
mm ²	AWG or kcmil	600 V	1000 V or 2000 V
2.08 – 5.26	14 – 10 AWG	3.0	6.0
8.37 – 33.6	8 – 2	3.5	7.5
42.4 – 107	1 – 4/0	4.0	9.0
Larger than 107 – 253	Larger than 4/0 – 500 kcmil	5.0	10.0
Larger than 253 – 507	Larger than 500 – 1000	6.0	11.0
Larger than 507 – 1010	Larger than 1000 – 2000	7.0	13.5

Table 45
Minimum insulation resistance at 15°C – R90, RW75, RW90, RWU75, and RWU90 – for all materials except R90, RW75, and RW90 employing silicone^a

(See 5.25 and Annex B)

Conductor size		RWU90, RWU75 with XL insulation		RWU75 and RWU90 (1000 V only) with EP insulation, and RW75, RW90, and R90				R90, RW75, and RW90	
		1000 V		600 V		1000 V		2000 V	
mm ²	AWG or kcmil	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft
	AWG								
2.08	14	2500	8200	1550	5090	2100	6890	2540	8330
3.31	12	2100	6890	1300	4270	1750	5740	2180	7150
5.26	10	1800	5910	1050	3440	1450	4760	1850	6070
8.37	8	1900	6230	1200	3940	1200	3940	1750	5740
13.3	6	1600	5250	1000	3280	1300	4270	1470	4820
21.2	4	1350	4430	850	2790	1050	3440	1230	4040
26.7	3	1200	3940	770	2530	980	3220	1120	3670
33.6	2	1100	3610	690	2260	890	2920	1020	3350

Table 45 Continued on Next Page

Table 45 Continued

Conductor size		RWU90, RWU75 with XL insulation		RWU75 and RWU90 (1000 V only) with EP insulation, and RW75, RW90, and R90				R90, RW75, and RW90	
		1000 V		600 V		1000 V		2000 V	
mm ²	AWG or kcmil	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft
42.4	1	1150	3770	740	2430	1000	3280	1130	3710
53.5	1/0	1050	3440	670	2200	920	3020	1030	3380
67.4	2/0	970	3180	600	1970	840	2760	930	3050
85.0	3/9	880	2890	540	1770	760	2490	840	2760
107	4/0	800	2620	490	1610	680	2230	760	2490
	kcmil								
127	250	840	2760	530	1740	700	2300	810	2660
152	300	770	2530	480	1570	650	2130	750	2460
177	350	720	2360	450	1480	600	1970	700	2300
203	400	680	2230	420	1380	570	1870	660	2170
253	500	620	2030	380	1250	510	1670	600	1970
304	600	640	2100	420	1380	470	1540	620	2030
355	700	590	1940	400	1310	440	1440	580	1900
380	750	580	1900	380	1250	430	1410	560	1840
405	800	560	1840	370	1210	410	1350	550	1800
456	900	530	1740	350	1150	390	1280	520	1710
507	1000	510	1670	330	1080	370	1210	490	1610
608	1250	510	1670	350	1150	410	1350	510	1670
760	1500	470	1540	320	1050	370	1210	470	1540
887	1750	430	1410	300	980	350	1150	440	1440
1010	2000	410	1350	280	920	320	1050	410	1350

^a See [Table 20](#) for acceptable insulation.

Table 46
Minimum insulation resistance at 15°C of 600 V or 1000 V^a Types RHW-2, RHH, RHW, XHHW-2, XHHW, XHH, SA, and SIS and 600 V Types SF, RW75, RW90, R90 wires and cables^b

(See [5.25](#) and Annex [B](#))

Conductor size		Type SA and SF wire with insulation thickness in accordance with Table 13		Type XHHW-2, XHHW, and XHH wires with insulation thickness in accordance with Table 12		Type SIS wire EPCV, CP, CPE and XL insulation thickness in accordance with Table 14		Type RHW-2, RHH, RHW, RW75, RW90, and R90 wires with insulation thickness in accordance with Table 15							
								SBR/IIR, silicone or silicone composite		CP, CPE		EP, EPCV, XL		Composite EP, XL, or EPCV inner with EPCV, XL, CP, CPE outermost	
mm ²	(AWG or kcmil)	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft	GΩ·m	MΩ·1000 ft
2.08	14	220	710	810	2660	80	270	430	1420	110	360	1080	3550	1080	3550
3.31	12	180	610	680	2240	70	220	370	1210	90	300	920	3030	920	3030
5.26	10	150	510	560	1850	55	190	310	1020	75	250	770	2540	770	2540

Table 46 Continued on Next Page

Table 46 Continued

Conductor size		Type SA and SF wire with insulation thickness in accordance with Table 13		Type XHHW-2, XHHW, and XHH wires with insulation thickness in accordance with Table 12		Type SIS wire EPCV, CP, CPE and XL insulation thickness in accordance with Table 14		Type RHW-2, RHH, RHW, RW75, RW90, and R90 wires with insulation thickness in accordance with Table 15							
								SBR/IIR, silicone or silicone composite		CP, CPE		EP, EPCV, XL		Composite EP, XL, or EPCV inner with EPCV, XL, CP, CPE outermost	
mm ²	(AWG or kcmil)	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft	GΩ·m	MΩ ·1000 ft
8.36	8	160	530	650	2130	65	210	320	1060	80	270	810	2650	810	2650
13.3	6	140	450	540	1780	55	180	270	900	70	220	680	2240	810	2650
21.2	4	110	370	450	1460	45	150	230	740	55	190	560	1850	680	2220
26.7	3	100	340	400	1330	40	130	210	680	50	170	520	1690	620	2030
33.6	2	95	310	370	1200	35	120	190	610	45	150	470	1530	560	1850
42.4	1	110	350	390	1280	40	130	210	700	55	180	530	1750	640	2100
53.5	1/0	95	320	350	1150	35	120	190	640	50	160	490	1590	580	1910
67.4	2/0	90	290	320	1040	30	100	180	580	45	150	440	1450	530	1740
85.0	3/0	85	260	290	940	30	95	160	520	40	130	400	1300	480	1580
107	4/0	70	240	260	850	25	85	140	470	45	120	460	1180	440	1450
127	250	80	255	280	910	—	—	160	510	40	130	390	1270	510	1660
152	300	70	240	260	840	—	—	140	470	35	120	360	1170	470	1540
177	350	65	220	240	780	—	—	130	440	35	110	340	1100	440	1440
203	400	65	210	220	730	—	—	130	410	30	100	320	1040	420	1360
226	450	60	200	210	700	—	—	120	390	30	100	300	980	400	1290
253	500	55	190	200	660	—	—	110	370	30	95	290	940	380	1240
279	550	60	200	230	770	—	—	120	410	30	100	310	1020	400	1300
304	600	60	200	220	740	—	—	120	390	30	100	300	980	380	1250
329	650	60	190	220	710	—	—	120	380	30	95	290	950	370	1210
355	700	55	180	210	690	—	—	110	370	30	90	280	920	360	1170
380	750	55	180	200	670	—	—	110	360	25	90	270	890	350	1140
405	800	55	170	200	640	—	—	110	350	25	85	260	863	340	1110
456	900	50	160	190	610	—	—	100	330	25	80	250	820	320	1050
507	1000	50	160	180	580	—	—	95	310	25	80	240	780	310	1000
557	1100	50	170	200	650	—	—	100	340	25	80	260	840	—	—
608	1200	50	160	190	630	—	—	100	320	25	80	240	800	—	—
633	1250	50	160	190	610	—	—	95	320	25	80	240	790	—	—
659	1300	50	160	180	600	—	—	95	310	25	80	240	780	—	—
709	1400	45	150	180	580	—	—	90	300	25	75	230	750	—	—
760	1500	45	150	170	560	—	—	90	290	20	75	220	730	—	—
811	1600	45	140	170	550	—	—	85	280	20	70	210	700	—	—
861	1700	40	140	160	530	—	—	85	270	20	70	210	690	—	—
887	1750	40	140	160	520	—	—	85	270	20	70	210	680	—	—
912	1800	40	130	160	520	—	—	80	270	20	65	200	670	—	—
963	1900	40	130	150	500	—	—	80	260	20	65	200	650	—	—
1010	2000	40	130	150	490	—	—	75	260	20	65	190	620	—	—

^a Applies to the United States only.^b See [Table 20](#) for acceptable insulation.

Table 47
Minimum insulation resistance at 15°C of 2000 V Types RHW-2, RHH, RHW, R90, RW75, and RW90
wires and cables^a

(See [5.25](#) and Annex [B](#))

Conductor size		For insulation thickness in accordance with Table 17									
		EP, EPCV, XL		CP, CPE		SBR/IIR		Composite EP, XL, or EPCV inner with EPCV, XL, CP, CPE outermost		Silicone or silicone composite	
mm ²	AWG or kcmil	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft
	AWG										
2.08	14	1310	4300	160	510	630	2050	1310	4300	520	1720
3.31	12	1130	3710	140	450	550	1790	1130	3710	450	1480
5.26	10	950	3120	120	380	470	1530	950	3120	380	1250
8.37	8	910	2980	100	330	400	1310	1040	3420	360	1190
13.3	6	770	2520	95	320	380	1260	890	2910	310	1010
21.2	4	640	2100	80	270	320	1060	740	2440	250	840
26.7	3	590	1920	75	240	300	980	680	2240	230	770
33.6	2	530	1750	70	220	270	890	620	2040	210	700
42.4	1	590	1930	70	230	280	910	690	2260	230	770
53.5	1/0	530	1750	65	210	250	830	630	2060	210	700
67.4	2/0	490	1600	55	190	230	750	570	1880	190	640
85.0	3/0	440	1450	50	170	210	680	520	1710	170	580
107	4/0	400	1310	45	160	190	620	470	1550	160	520
	kcmil										
127	250	420	1390	50	160	200	640	540	1770	170	550
152	300	390	1280	45	150	180	600	500	1640	150	510
177	350	370	1200	40	140	170	560	470	1530	150	480
203	400	350	1130	40	130	160	530	440	1450	140	450
226	450	330	1070	40	130	150	500	420	1380	130	430
253	500	310	1030	35	120	150	480	400	1320	140	410
279	550	340	1100	40	130	150	510	420	1380	135	440
304	600	320	1060	35	120	150	490	410	1330	130	420
329	650	310	1030	35	120	140	470	390	1280	120	410
355	700	300	990	35	110	140	460	380	1240	120	390
380	750	290	960	35	110	130	440	370	1210	110	380
405	800	290	930	35	110	130	430	360	1170	110	370
456	900	270	890	30	100	120	410	340	1110	110	350
507	1000	260	850	30	95	120	390	320	1060	100	340
557	1100	275	905	30	90	110	360	390	1295	110	370
608	1200	265	865	25	85	105	345	380	1250	110	360
633	1250	260	850	25	85	105	340	370	1225	100	350
659	1300	255	840	25	85	100	335	365	1205	100	340
709	1400	245	810	25	80	100	325	355	1165	100	330
760	1500	240	785	25	80	95	315	345	1130	95	320

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Table 47 Continued

Conductor size		For insulation thickness in accordance with Table 17									
		EP, EPCV, XL		CP, CPE		SBR/IIR		Composite EP, XL, or EPCV inner with EPCV, XL, CP, CPE outermost		Silicone or silicone composite	
mm ²	AWG or kcmil	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft	GΩ·m	MΩ·10-00 ft
811	1600	230	760	20	75	90	305	335	1100	95	310
861	1700	225	740	20	74	90	295	325	1070	90	300
887	1750	220	730	20	70	90	290	320	1055	90	300
912	1800	220	720	20	70	90	290	315	1040	90	300
963	1900	215	705	20	70	85	280	310	1020	90	300
1010	2000	210	685	20	70	85	275	300	990	85	290

^a See [Table 20](#) for acceptable insulation.

Table 48
Thickness of overall jacket on deep-well water pump cable

(See [7.2.4](#) and [7.2.6.2](#))

Calculated diameter of cable under jacket		Thickness of jacket			
		Minimum average		Minimum at any point	
mm	inch	mm	mils	mm	mils
Up to 17.8	Up to 0.700	1.14	45	0.91	36
17.9 – 26.7	0.701 – 1.051	1.52	60	1.21	48
26.8 – 38.1	1.052 – 1.500	2.03	80	1.62	64
38.2 – 50.1	1.501 – 1.972	2.41	95	1.93	76
50.2 – 76.2	1.973 – 3.000	2.79	110	2.23	88
76.3 and larger	3.001 and larger	3.18	125	2.54	100

Note: For flat cable, the calculated major core dimension under the jacket shall be used to determine the jacket thickness required.

Table 49
Conductor stranding

(See Clause [6.1.5](#).)

Conductor size		Number of strands					
		Copper		Aluminum		Copper-clad aluminum	
mm ²	(AWG or kcmil)	Class B	Class C	Class B	Class C	Class B	Class C
2.08 – 33.6	(14 – 2)	7	19	7 ^a	19 ^a	7 ^a	19 ^a
42.4 – 107	(1 – 4/0)	19	37	19	37	19	37
127 – 253	(250 – 500)	37	61	37	61	37	61
304 – 507	(600 – 1000)	61	91	61	91	61	91
633 – 760	(1250 – 1500)	91	127	–	–	–	–

Table 49 Continued on Next Page

Table 49 Continued

Conductor size		Number of strands					
		Copper		Aluminum		Copper-clad aluminum	
mm ²	(AWG or kcmil)	Class B	Class C	Class B	Class C	Class B	Class C
887 – 1010	(1750 – 2000)	127	169	–	–	–	–

^a Aluminum and copper-clad aluminum 14 AWG (2.08 mm²) are not available.

Note: In Canada and Mexico, copper-clad aluminum conductors shall not be used in thermoset-insulated wires and cables.

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Annex A (informative) – Conductor types covered by this Standard

(See [1.1](#))

Wire type designation	Voltage rating, V	Electrical code recognition		
		Canadian	Mexican	U.S.
XHHW-2	600	No	Yes	Yes
XHHW	600 or 1000 ^a	No	Yes	Yes
XHH	600	No	No	Yes
RHH	600, 1000 ^a or 2000	No	Yes	Yes
RHW-2	600 or 2000	No	Yes	Yes
RHW	600, 1000 ^a or 2000	No	Yes	Yes
SA	600	No	No	Yes
SF	600	No	Yes	No
SIS	600	Yes	Yes	Yes
R90	600, 1000, 2000, or 5000	Yes	No	No
RW75	600, 1000, 2000, or 5000	Yes	No	No
RW90	600, 1000, 2000, or 5000	Yes	No	No
RWU75	1000	Yes	No	No
RWU90	1000	Yes	No	No

^a Applies to the United States only.

Note: See Annex [B](#) for a summary of construction and test requirements and the grouping of different wire types with identical requirements.

Annex B (informative) – Summary of requirements

(See [1.1](#))

Table B.1

Requirement	Wire type designation								
	XHH	XHHW, XHHW-2	RHW, RHW-2	RHH	SA, SF ^b	SIS	R90	RW75, RW90	RWU75, RWU90
Voltage rating	600 V and 1000 V ^a		600 V, 1000 V ^a and 2000 V		600 V and 1000 V ^a		600 V, 1000 V, 2000 V and 5000 V ^c		1000 V
Temperature rating	1.2, Table 1								
Conductors	4.1.5.1, Table 2								
Number of conductors	Table 1								
Conductor stranding	4.1.5.2, Table 3								
Conductor diameter	4.1.6, Table 5 – Table 10								
Conductor separator	4.1.8								
Insulation – General	4.2.1, Table 20								
Insulation – Physical properties	4.2.1, Table 11								
Insulation – Thickness	4.2.3, Table 12 – Table 18								
Jackets and coverings	4.3, Table 22 – Table 24								
Jacket physical properties	Table 21								
Shielding	4.4								
Multiple-conductor cables	4.5								
Color coding	4.6								
Fillers	4.7								
Jacket separators	4.8								
Overall jackets	4.9, Table 20 and Table 27								
Evaluation of new materials	4.10								
Assemblies of conductors	4.11								
Conductor resistance	5.2, Table 28 – Table 33								
Tests on aluminum conductors	5.3								
Long-term insulation resistance in water		5.4, Table 36						5.4, Table 34 – Table 35	
Long-term insulation resistance in air for 90°C rated conductors	5.5, Table 37			5.5, Table 37			5.5, Table 37 – Table 38		
Capacitance and relative permittivity		5.6						5.6	

Table B.1 Continued on Next Page

Table B.1 Continued

Requirement	Wire type designation								
	XHH	XHHW, XHHW-2	RHW, RHW-2	RHH	SA, SF ^b	SIS	R90	RW75, RW90	RWU75, RWU90
Conductor corrosion	5.7								
Insulation fall-In	5.8								
Heat shock of thermoplastic jacket	5.9								
Flexibility of separator under thermoplastic jacket	5.10								
Cold bend	5.11.1								
Cold impact (optional)	5.11.2								
Deformation	5.12								
Hot creep	5.13								
Horizontal-specimen flame test	5.14.1								
Burning particles test	5.14.2								
FT1 flame test (optional)	5.14.3								
VW-1 flame test (optional)	5.14.4								
Vertical tray flame (optional)	5.14.5								
FT4 vertical tray flame (optional)	5.14.6								
ST1 limited smoke (optional)	5.14.7								
LS (low smoke), flame, smoke, and acid gas release (optional)	5.14.8								
Weather resistance (optional)	5.15								
Oil resistance (optional)	5.16								
Gasoline and oil resistance (optional)	5.17								
Crushing resistance	5.18								
Glancing impact	5.19								
Durability of ink printing	5.20								
Shrinkback	5.21							5.21	
Evaluation of new materials	5.22								
Spark test	5.23 , Table 43								
Dielectric voltage-withstand test	5.24 , Table 44								

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Table B.1 Continued

Requirement	Wire type designation								
	XHH	XHHW, XHHW-2	RHW, RHW-2	RHH	SA, SF ^b	SIS	R90	RW75, RW90	RWU75, RWU90
Insulation resistance in water, 15°C	5.25 , Table 45 – Table 47								
Electrical continuity	5.26								
Markings on product	6.1								
Markings on package	6.2								
Deep-well submersible pump cable	7								

^a Applies to the United States only.

^b SF rated 600 V only.

^c For 5000 V, refer to Annex [K](#).

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Annex C (normative) – Chemical composition of aluminum conductors

(See [1.1](#))

Table C.1
Chemical composition of ACM, AA 8000 series aluminum alloy conductor materials

Maximum or range composition, percent mass										
Alloys		Elements							Others	
ANSI	UNS	Aluminum	Silicon	Iron	Copper	Magnesium	Zinc	Boron	Each	Total
8017	A98017	Remainder	0.10	0.55 to 0.8	0.10 to 0.20	0.01 to 0.05	0.05	0.04	0.03 ^a	0.10
8030	A98030	Remainder	0.10	0.30 to 0.8	0.15 to 0.30	0.05	0.05	0.001 to 0.04	0.03	0.10
8076	A98076	Remainder	0.10	0.6 to 0.9	0.04	0.08 to 0.22	0.05	0.04	0.03	0.10
8130	A98130	Remainder	0.15 ^a	0.40 to 1.0 ^b	0.05 to 0.15	–	0.10	–	0.03	0.10
8176	A98176	Remainder	0.03 – 0.15	0.40 to 1.0	–	–	0.10	–	0.05 ^c	0.15
8177	A98177	Remainder	0.10	0.25 to 0.45	0.04	0.04 to 0.12	0.05	0.04	0.03	0.10
^a 0.003 max lithium ^b 1.0 max silicon and iron ^c 0.03 max gallium										

Table C.2
Chemical composition of aluminum 1350 conductors

Element	Symbol	Composition, maximum percent by mass
Silicon	Si	0.10
Iron	Fe	0.40
Copper	Cu	0.05
Gallium	Ga	0.03
Manganese	Mn	0.01
Boron	B	0.05
Vanadium and titanium	V + Ti	0.02
Chromium	Cr	0.01
Zinc	Zn	0.05
Others (each)	–	0.03
Others (total)	–	0.10
Aluminum	Al	Remainder (99.50 minimum)

Annex D (normative) – Copper-clad aluminum conductors

(See [4.1.3](#))

D.1 General

The copper cladding shall be metallurgically bonded to the aluminum core, shall occupy 10 percent or more of the cross-section of a solid conductor, and of each wire (strand) of a stranded conductor, and shall be concentric with the aluminum. The thickness of the copper shall not be less than 2.56 percent of the diameter of the solid conductor or wire (strand) as determined by microscopic examination of a polished right cross-section of the round strand or round solid conductor.

D.2 Sizes and stranding

Conductors shall be of the same size and assembly indicated for solid or concentric stranded aluminum wire in [Table 2](#). The number of wires in the conductors shall be in accordance with [Table 3](#).

D.3 Conductor resistance

The direct-current resistance of the copper-clad aluminum conductor shall not be greater than as specified for aluminum conductors in [Table 29](#) and [Table 30](#), as appropriate.

D.4 Physical properties

The tensile strength of a finished copper-clad aluminum conductor tested as a unit or of the wires (strands) from a finished stranded copper-clad aluminum conductor and of a solid copper-clad aluminum conductor shall not exceed 138 MPa (20,000 lbf/in²) when specimens are tested at a maximum separation speed of 300 mm/min (12 in/min). The elongation of the same specimens shall not be less than 15 percent. The bench marks for the tensile and elongation test shall be placed 250 mm (10 in) apart.

D.5 Marking requirements

D.5.1 In addition to the marking required in [6.1](#) and [6.2](#), copper-clad aluminum conductors shall be marked "AL (CU-CLAD)" or "CU-CLAD AL" wherever the size of the conductor appears on the wire, cable, or the package marking.

D.5.2 The following statements shall also appear on the package:

- a) "Copper-clad aluminum shall be used only with equipment marked to indicate that it is for use with aluminum conductors. Terminate copper-clad aluminum with pressure wire connectors marked for use with copper and aluminum conductors."
- b) For 3.31 – 5.26 mm² (12 – 10 AWG) solid copper-clad aluminum: "May be used with wire-binding screws and in pressure-plate and push-in spring-type connecting mechanisms that are acceptable for use with copper conductors".
- c) "Where physical contact between any combination of copper-clad aluminum, copper, and aluminum conductors occurs in a wire connector, the connector shall be of a type marked for such intermixed use and the connection shall be limited to dry locations only".

Annex E (informative) – Metric sizes

(See [4.1.5.1](#))

Note: This Annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.

E.1 Metric sizes for wire and cable products are not recognized in the *Canadian Electrical Code, Part I*, the *Standard for Electrical Installations*, and the *National Electrical Code*, but are employed in some jurisdictions requiring metric sized conductors. [Table E.1](#) and [Table E.2](#) are based on IEC 60228.

E.2 The direct-current resistance values of conductors shall not be greater than given in [Table E.3](#), except that a plus tolerance of 2 percent is permitted in the case of a conductor in a twisted multiple-conductor cable assembly.

E.3 Direct-current resistance shall be determined in accordance with the test, DC Resistance, in UL 2556, CSA C22.2 No. 2556, or NMX-J-212-ANCE.

E.4 The thickness of insulation and jackets and other related requirements shall be the same as those that correspond to the AWG or kcmil closest to the metric conductor size (mm²) as shown in [Table E.4](#).

Table E.1
Solid Class 1 aluminum and copper conductors

(See [E.1](#))

Conductor area		Maximum diameter, mm
Square millimeters	Circular mils	
0.50	992	0.9
0.75	1 458	1
1	1 980	1.2
1.5	2 952	1.5
2.5	4 856	1.9
4	7 777	2.4
6	11 637	2.9
10	19 644	3.7
16	31 109	4.6
25	49 305	5.7
35	68 339	6.7
50	92 378	7.8
70	133 484	9.4
95	185 171	11
120	234 119	12.4
150	287 532	13.8

Table E.2
Concentric-stranded Class 2 aluminum and copper conductors

(See [E.1](#))

Conductor area		Minimum number of strands				Maximum diameter, mm
		Non-compact		Compact		
Square millimeters	Circular mils	Cu	Al	Cu	Al	
0.50	1 043	7	—	—	—	1.1
0.75	1 485	7	—	—	—	1.2
1	2 101	7	—	—	—	1.4
1.5	3 048	7	—	6	—	1.7
2.5	4 871	7	—	6	—	2.2
4	7 839	7	7	6	—	2.7
6	11 735	7	7	6	—	3.3
10	19 774	7	7	6	6	4.2
16	31 357	7	7	6	6	5.3
25	49 689	7	7	6	6	6.6
35	68 902	7	7	6	6	7.9
50	93 310	19	19	6	12	9.1
70	134 869	19	19	12	15	11
95	187 020	19	19	15	18	12.9
120	236 334	37	37	18	18	14.5
150	290 335	37	37	18	30	16.2
185	364 196	37	37	30	34	18
240	478 660	61	61	34	34	20.6
300	600 431	61	61	34	53	23.1
400	767 984	61	61	53	53	26.1
500	968 194	61	61	53	53	29.2
630	1 250 079	61	91	53	53	33.2
800	1 598 917	61	91	53	53	37.6
1 000	2 015 748	61	91	53	53	42.2

Table E.3
Maximum DC resistance in ohms per kilometer at 20°C

(See [E.2](#))

Conductor size, mm ²	Solid (Class 1)			Stranded (Class 2)		
	Aluminum	Copper		Aluminum	Copper	
		Uncoated	Coated		Uncoated	Coated
0.50	—	36.0	36.7	—	36.0	36.7
0.75	—	24.5	24.8	—	24.5	24.8
1	—	18.1	18.2	—	18.1	18.2
1.5	18.1	12.1	12.2	—	12.1	12.2
2.5	12.1	7.41	7.56	—	7.41	7.56
4	7.41	4.61	4.70	7.41	4.61	4.70
6	4.61	3.08	3.11	4.61	3.08	3.11
10	3.08	1.83	1.84	3.08	1.83	1.84
16	1.91	21.2	1.16	1.91	21.2	1.16

Table E.3 Continued on Next Page

Table E.3 Continued

Conductor size, mm ²	Solid (Class 1)			Stranded (Class 2)		
	Aluminum	Copper		Aluminum	Copper	
		Uncoated	Coated		Uncoated	Coated
25	1.20	0.727	—	1.20	0.727	0.734
35	0.868	0.524	—	0.868	0.524	0.529
50	0.641	0.387	—	0.641	0.387	0.391
70	0.443	0.268	—	0.443	0.268	0.270
95	0.320	0.193	—	0.320	0.193	0.195
120	0.253	0.153	—	0.253	0.153	0.154
150	0.206	0.124	—	0.206	0.124	0.126
185	0.164	—	—	0.164	0.0991	0.100
240	0.125	—	—	0.125	0.0754	0.0762
300	0.100	—	—	0.100	0.0601	0.0607
400	—	—	—	0.0778	0.0470	0.0475
500	—	—	—	0.0605	0.0366	0.0369
630	—	—	—	0.0469	0.0283	0.0286
800	—	—	—	0.0367	0.0221	0.0224
1 000	—	—	—	0.0291	0.0176	0.0177

Table E.4
Closest AWG or kcmil size(s) to metric conductor size(s)

(See E.4)

Metric conductor size, mm ²	Closest AWG or kcmil size(s) for selection of insulation and jacket thickness requirement
2.5	14
4	12
6	10
10	8
16	6
25	4
35	2
50	1/0
70	2/0
95	3/0
120	250
150	300
240	500
300	600
400	800
500	1000
630	1250
800	1500
1000	2000

Note: While this table is provided to permit the correct selection of insulation and jacket thickness requirements, which are dependent on conductor size, the CE Code, Part I, NOM-001-SEDE, and NEC do not provide ampacity values for the metric conductor sizes shown above at the time of publication.