UL 1569

STANDARD FOR SAFETY

Metal-Clad Cables

UL Standard for Safety for Metal-Clad Cables, UL 1569

Fifth Edition, Dated May 4, 2018

Summary of Topics

This is the new harmonized edition of UL 1569/NMX-J-726-ANCE for use in Mexico and the United States. The requirements of this Standard are in accordance with Article 330 of the National Electrical Code in the United States, and Article 330 of the Standard for Electrical Installations, NOM-001-SEDE in Mexico, and that the requirements do not cover medium voltage cables covered in UL 1072 or NMX-J-142/1-ANCE.

The new requirements are substantially in accordance with Proposal(s) on this subject dated August 11, 2017 and January 26, 2018.

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Association of Standardization and Certification
NMX-J-726-ANCE
First Edition

Underwriters Laboratories Inc.
UL 1569
Fifth Edition

Metal-Clad Cables

May 4, 2018

ANSI/UL 1569-2018

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE and UL. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the UL pages.

This ANSI/UL Standard for Safety consists of the Fifth Edition. The most recent designation of ANSI/UL 1569 as an American National Standard (ANSI) occurred on May 4, 2018. 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 1569 on July 23, 1983. 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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CONTENTS

PREFACE

This is the harmonized ANCE and UL standard for Metal-Clad Cables. It is the first edition of NMX-J-726-ANCE, and the fifth edition of UL 1569. This edition of UL 1569 supersedes the previous edition published on November 13, 2014.

This harmonized standard was prepared by the Association of Standardization and Certification, (ANCE) and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Subcommittee 20, Building Wire and Cable 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, Electric Cables from the Comite de Normalizacion de la Asociacion de Normalizacion y Certificacion, A.C., CONANCE, with the collaboration of CANAME member manufacturers and users.

This standard will be submitted to the American National Standards Institute (ANSI) for publication 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 is published as an equivalent standard for ANCE and UL.

Metal-Clad Cables

1 Scope

1.1 These requirements cover round or flat metal-clad cables that contain 0.824 – 1010 mm^2 (18 AWG – 2000 kcmil) insulated circuit conductors with or without one or more optical-fiber members, all enclosed in armor consisting of interlocked metal strip or a smooth or corrugated metal tube. Round cables contain one or more insulated circuit conductors. Flat cable contains two or three insulated circuit conductors. These electrical and hybrid electrical/optical-fiber cables are for use (optical and electrical functions associated in the case of a hybrid cable) as Type MC cable in accordance with Article 330 and other applicable parts of the National Electrical Code, NFPA 70 and in accordance with Article 330 of the Standard for Electrical Installations, NOM-001-SEDE.

Note 1: In the United States, Type AC armored cables are covered in the Standard for Armored Cables, UL 4.

Note 2: In the United States, metal-clad cables for use in Division 1 and Zone 1 hazardous locations are required to comply with this Standard and the Standard for Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations, UL 2225.

1.2 These requirements cover round or flat armored cables that have thermoplastic or thermoset insulation at voltage ratings not exceeding 600 V (thermoplastic) or 600 or 2000 V (thermoset) where subjected to temperatures not exceeding 75°C or 90°C , depending upon the voltage and temperature ratings of the circuit conductors in the cable. Cables with 600 V conductors that also include one or more optical-fiber members have ″-OF″ supplementing the type letters and are limited to carrying optical energy that has been ruled not hazardous to the human body.

1.3 These requirements do not cover Type MV (medium-voltage) cables rated for 2400 – 35000 V, which are covered in the Standard for Medium-Voltage Cables, UL 1072 or NMX-J-142/1-ANCE. A multiple-conductor Type MV cable with a smooth (other than lead) or corrugated metal sheath or with interlocked metal armor may be marked for use also as Type MC cable.

1.4 These requirements do not cover the optical or other performance of any optical-fiber member or group of such members.

2 Definitions

2.1 The following definitions apply in this Standard:

2.2 ETFE and ECTFE – Thermoplastic materials whose characteristic constituent is either a copolymer of ethylene and tetrafluoroethylene (ETFE) or a copolymer of ethylene and chlorotrifluoroethylene (ECTFE). The material is uncompounded ECTFE or ETFE to which a small amount of pigment, lubricant, or both, is or is not added.

2.3 mPPE – A compounded thermoplastic material whose characteristic constituent is: Poly (2,6-dimethyl-1,4-phenylene ether).

2.4 PVC – A thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride or vinyl acetate.

2.5 PVDF – A thermoplastic material whose characteristic constituent is the homopolymer resin polyvinylidene fluoride. The material is uncompounded PVDF to which it is appropriate to add a small amount of pigment, lubricant, or both.

2.6 PVDF COPOLYMER – A thermoplastic material whose characteristic constituent is a copolymer of polyvinylidene fluoride and hexafluoropropylene. The material is the uncompounded copolymer to which it is appropriate to add a small amount of pigment, lubricant, or both.

2.7 SEMIRIGID PVC (SRPVC) – A partially plasticized thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride or vinyl acetate.

2.8 TPE – An extensible compound whose characteristic constituent is a thermoplastic elastomer.

2.9 TPU – Thermoplastic polyurethane, a compounded thermoplastic elastomer material whose characteristic constituent is a polyester- or polyester-based urethane linear polymer resin characterized by soft amorphous segments containing hard crystalline microdomains.

2.10 Type MC – Also known as metal-clad cable for the purpose of this standard, a factory assembly of one or more insulated circuit conductors with or without one or more optical-fiber members, all of which are enclosed in an armor consisting of interlocked metal strip or a smooth or corrugated metallic sheath, with or without an overall jacket.

3 General

3.1 Units of measure

3.1.1 The unit of measure shall be SI. If a value for measurement is followed by a value in other units in parentheses, the second value represents a direct conversion or an alternative value. Except for conductor size, the first stated value is the requirement.

3.2 Compliance

3.2.1 Metal-clad cable shall be designated as Type MC and shall comply in all respects with the applicable requirements for construction details, test performance, and markings.

3.3 Materials

3.3.1 The insulation in each of the following cables shall be of a material that is acceptable for use in wet locations if the cable has armor consisting of interlocked metal strip, but does not include a jacket over the assembly under the armor:

a) Cable that is marked for direct burial, and

b) Cable that is intended for use in wet locations.

3.4 Reference publications

3.4.1 This Standard refers to the following publications and where reference is made to ANCE or UL Standards, such reference shall be considered to refer to the latest edition and all amendments published to that edition. Where such reference is made to other publications, it shall be to the edition listed below.

ANCE (Association of Standardization and Certification)

NMX-J-010-ANCE
Wires and Cables – Thermoplastic Insulated Wires and Cables – Specifications

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

NMX-J-036-ANCE
Wires and Cables – Soft or Annealed Copper Wire for Electrical Purposes – Specifications

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

NMX-J-142/1-ANCE
Wires and Cables – Shielded Power Cables, Rated 5Kv through 35Kv, Cross-Linked Polyethylene or Ethylene-Propylene Rubber Insulated – Specifications and Test Methods

NMX-J-177-ANCE
Wires and Cables – Determination of the Thicknesses in Semiconducting 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 Methods

NMX-J-191-ANCE
Wire and Cables – Heat Distortion of Insulations And Protective Jackets of Electrical Conductors – Test Method

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

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

NMX-J-300-ANCE
Wires and Cables – Control Cables – Specifications

NMX-J-451-ANCE
Wires and Cables – Thermoset Insulated Wires and Cables – Specifications

NMX-J-472-ANCE
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-474-ANCE
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-516-ANCE
Wires and Cables – Determination of Direction and Length of Lay of Bare and Insulated Conductors – Test Method

NMX-J-532-ANCE
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-543-ANCE
Connectors – Wires Connectors – Specification and Test Method

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

NMX-J-556-ANCE
Wires and Cables – Test Methods

Steel Chamber of Mexico

NMX-H-014
Test Method for Determining the Weight of Zinc Coating in Galvanized Steel Products

Secretary of Energy

NOM-001-SEDE
Standard for Electrical Installations

ASTM International (ASTM) Standards

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

B800
Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes – Annealed and Intermediate Tempers

B566-04a
Standard Specification for Copper-Clad Aluminum Wire

D471
Standard Test Method for Rubber Property-Effect of Liquids

D5025-99
Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials

D5207-98
Standard Practice for Calibration of 20 and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials

NFPA Standards

NFPA 70-2017
National Electrical Code

UL (Underwriters Laboratories Inc.) Standards

UL 44
Thermoset-Insulated Wire and Cable

UL 66
Fixture Wire

UL 83
Thermopolastic-Insulated Wire and Cable

UL 83A
Fluoropolymer Insulated Wire

UL 486A-486B
Wire Connectors

UL 1072
Medium-Voltage Power Cables

UL 1277
Electrical Power and Control Tray Cables with Optional Optical-Fiber Members

UL 1685
Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

UL 2225
Cables and Cable Fittings for Use In Hazardous (Classified) Locations

UL 2556
Wire and Cable Test Methods

4 Construction

4.1 Conductors

4.1.1 General

4.1.1.1 Only copper, nickel-based alloy, copper-clad aluminum, or an acceptable aluminum alloy shall be used for the conductors in a cable. Soft-annealed copper shall comply with the Standard Specification for Soft or Annealed Copper Wire, ASTM B3 or NMX-J-036-ANCE.

4.1.1.2 Solid aluminum conductors in size 3.31 – 8.37 mm^2 (12 – 8 AWG) shall comply with the requirements for aluminum-wire stock (aluminum-alloy conductor material) in Annex A and in ASTM B800 or NMX-J-532-ANCE .

4.1.1.3 Stranded aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in ASTM B800 or NMX-J-533-ANCE when tested in accordance with the test Resistance of armor in UL 2556 or NMX-J-177-ANCE.

4.1.1.4 Copper-clad aluminum conductors shall comply with the requirements in Annex B. In a given cable, all conductors are not required to be of the same metal.

In Mexico, copper-clad aluminum is not recognized.

4.1.1.5 A copper conductor shall not be smaller than 0.824 mm^2 (18 AWG) and shall not be larger than 1010 mm^2 (2000 kcmil). An aluminum conductor shall not be smaller than 3.31 mm^2 (12 AWG) and shall not be larger than 1010 mm^2 (2000 kcmil).

4.1.1.6 Each 13.3 – 1010 mm^2 (6 AWG – 2000 kcmil) conductor shall be stranded. The 0.824 mm^2 (18 AWG) and larger copper or 3.31 mm^2 (12 AWG) and larger aluminum conductors shall comply with the requirements in 4.1 in UL 44 or NMX-J-451-ANCE, or in 4.1 of UL 83 or NMX-J-010-ANCE, except as modified in this Section.

In the United States, 0.824 or 1.3 mm^2 (18 or 16 AWG) copper conductors shall comply with the requirements for fixture wire in UL 66.

In Mexico, 0.824 or 1.3 mm^2 (18 or 16 AWG) copper conductors shall comply with the requirements for control cables in NMX-J-012-ANCE.

4.1.2 Joints

4.1.2.1 Any joint in a conductor shall comply with UL 83 or NMX-J-010-ANCE; UL 44 or NMX-J-451-ANCE; or UL 66 or NMX-J-300-ANCE, as applicable, except that a splice is acceptable in an 0.824 – 8.37 mm^2 (18 – 8 AWG) stranded conductor as a whole if the splice (butt splice) is made by machine brazing or welding such that the resulting solid section of the stranded conductor is not longer than 13 mm (1/2 in), the splice does not increase the diameter of the conductor, there are no sharp points, and the distance between splices in a single conductor does not average less than 915 m (3000 ft) in any reel length of that single insulated conductor.

4.1.2.2 A butt splice shall be made before insulating or after insulating and prior to further processing. Butt splices of stranded conductors made after insulating and splices of insulated solid conductors made with other than the original insulation shall be the subject of an investigation that includes tests to determine that all electrical, physical, and mechanical properties of the original system of insulation and any jacket on the conductor have been restored at the point of each splice.

4.1.2.3 All finished, insulated stranded conductors containing a butt splice or splice made with other than the original insulation shall not be marked with a Type designation according to the NEC or NOM-001-SEDE, but the following are acceptable:

a) Polarity Identification – Color coding, surface printing, or both, of hash marks, numbers, color names, or the like.

b) Ratings On Conductors with no Type designation according to the NEC or NOM-001-SEDE – Surface marking of the 6.7.1(c)(1) temperature and dry/wet ratings from Table 7.

4.1.3 Grounding conductors

4.1.3.1 Cable having interlocked armor, not intended to be used as a ground path, shall contain one copper, aluminum, or copper-clad aluminum grounding conductor that is in one location or in several sections (see 4.1.3.6) and is not smaller than indicated under the heading ″Grounding Conductor″ in Table 3 or 5 [90°C circuit conductors] or in Table 4 or 6 [75°C circuit conductors]. One or more additional copper, aluminum, or copper-clad aluminum grounding conductors may be provided. See Table 7 for appropriate wet and dry ratings.

In Mexico, copper-clad aluminum conductors are not recognized.

4.1.3.2 Each additional grounding conductor shall not be sectioned and shall not be smaller than indicated in Table 3 or 4. If only one grounding conductor is provided, it may be bare or it may be insulated in accordance with 6.6.1. If more than one grounding conductor is provided, one grounding conductor (the required conductor) may be bare or insulated and every other grounding conductor shall be insulated in accordance with 6.9.2 or 6.9.3. See 4.1.3.7.

4.1.3.3 Cable with 0.824 – 13.3 mm^2 (18 – 6 AWG) insulated conductors having interlocked armor that is intended for use as a ground path, shall contain a bare aluminum grounding/bonding conductor cabled with the insulated conductors. The grounding/bonding conductor is of a size such that the measured resistance of the grounding /bonding conductor when connected in parallel with the armor is not higher than indicated in one of the last four columns of Table 3 or 4 when tested in accordance with the test Resistance of armor in UL 2556 or NMX-J-556-ANCE. Cable with interlocked armor and a binder tape in accordance with 4.3.7.1 – 4.3.7.5 shall have the grounding/bonding conductor positioned over the binder tape and located in one of the interstices and in direct contact with the interlocked armor. Cable with interlocked aluminum or zinc-coated steel armor and insulated conductors with a protective covering in accordance with 4.3.7.6 shall have the bare aluminum grounding/bonding conductor laid (cabled or

straight) with the insulated conductors and in direct contact with the interlocked armor. A protective covering shall not be required for groups of insulated conductors under a binder jacket in accordance with 4.3.3 or enclosed in an inner jacket in accordance with 4.3.4. See Table 7 for appropriate wet and dry ratings. The grounding/bonding conductor shall not be smaller than indicated under the heading ″Grounding conductor″ in Table 3 [90°C circuit conductors] or in Table 4 [75°C circuit conductors] and shall not be sectioned. One or more additional copper, aluminum, or copper-clad aluminum grounding conductors may be provided. Each additional grounding conductor shall not be sectioned and shall not be smaller than indicated in Table 3 or 4. If an additional grounding conductor is provided, it shall be insulated in accordance with 6.9.1 – 6.9.3. See 4.1.3.7.

In Mexico, copper-clad aluminum conductors are not recognized.

4.1.3.4 Cable having corrugated- or smooth-sheath armor with a resistance greater than indicated in one of the last four columns of Table 3 or 5 [90°C circuit conductors] or in Table 4 or 6 [75°C circuit conductors] shall contain one copper, aluminum, or copper-clad aluminum grounding conductor that is in one location or in several sections (see 4.1.3.6) and is of a size such that the measured resistance of the grounding conductor when connected in parallel with the armor is not higher than indicated in one of the last four columns of Table 3 or 4. One or more additional copper, aluminum, or copper-clad aluminum grounding conductors may be provided. Each additional grounding conductor shall not be sectioned and shall not be smaller than indicated in Table 3 or 4. If only one grounding conductor is provided, it shall be bare or it shall be insulated in accordance with 6.9.1. If more than one grounding conductor is provided, one grounding conductor (the required conductor) shall be bare or insulated and every other grounding conductor shall be insulated in accordance with 6.9.2 or 6.9.3. See 4.1.3.7.

In Mexico, copper-clad aluminum conductors are not recognized.

4.1.3.5 Cable having corrugated- or smooth-sheath armor that has a resistance equal to or lower than indicated in one of the last four columns of Tables 3 – 6, when tested in accordance with the test Resistance of armor in UL 2556 or NMX-J-556-ANCE, may contain one or more copper, aluminum, or copper-clad aluminum grounding conductors. Each grounding conductor shall not be smaller than indicated under the heading ″Grounding conductor″ in Table 3 [90°C circuit conductors] or in Table 4 [75°C circuit conductors]. If only one grounding conductor is provided, it may be bare and may be sectioned (see 4.1.3.6) or it may be insulated in accordance with 6.9.1. If more than one grounding conductor is provided, one grounding conductor may be bare and may be sectioned (see 4.1.3.6) and every other grounding conductor shall not be sectioned and shall be insulated in accordance with 6.9.2 or 6.9.3. See 4.1.3.7.

In Mexico, copper-clad aluminum conductors are not recognized.

4.1.3.6 A grounding conductor in a multiple-conductor cable shall not be distributed helically (concentric). A copper grounding conductor smaller than 2.08 mm^2 (14 AWG) shall not be sectioned. No part of a sectioned grounding conductor shall be smaller than 0.824 mm^2 (18 AWG).

4.1.3.7 Grounding-conductor insulation and any covering over that insulation shall comply with Construction, Section 4, as if the insulated grounding conductor were a circuit conductor and shall comply with 4.3.2.1. Any or all additional insulated grounding conductors (these are insulated grounding conductors that are not required, but are provided in accordance with 4.1.3.1, 4.1.3.2, 4.1.3.4, or 4.1.3.5) may be designated as isolated-grounding conductors, with the outer surface of each such conductor marked as indicated in 6.10. See 4.3.2.7 (cabling) and 6.3.2 (color), and 6.7.1(k) (tag marking).

4.1.4 Compact-stranded sector conductors

4.1.4.1 Compact-stranded, sector conductors shall be shaped as a 120 degree segment of a circle.

4.1.4.2 Compact-stranded, sector conductors shall comply with all of the requirements specified in 4.1.1 – 4.1.3, with the following exceptions:

a) Sector conductors shall be limited to sizes 53.5 – 380 mm^2 (1/0 AWG – 750 kcmil).

b) The conductor size shall be determined according to the test DC resistance in UL 2556 or NMX-J-212-ANCE.

c) For purposes of calculating lay length, the effective diameter of the conductor shall be determined by adding the lengths of the conductor's major and minor axes and dividing by 2. The major axis is defined as the distance from top of the arc to bottom tip, and the minor axis is defined as the distance from left tip to right tip.

4.1.5 Circuit conductors

4.1.5.1 General

4.1.5.1.1 Each circuit conductor shall be either a Type designation recognized in the NEC or NOM-001-SEDE as shown in 4.1.4.2 or a conductor not recognized as a NEC or NOM-001-SEDE Type as shown in 4.1.6.

4.1.5.2 NEC or NOM-001-SEDE types

4.1.5.2.1 Each circuit conductor that is an NEC or NOM-001-SEDE type shall comply with this Standard and shall be one of the types in Table 1 or 2:

a) 2.08 – 107 mm^2 (14 – 4/0 AWG) and 127 – 1010 mm^2 (250 – 2000 kcmil) circuit types complying with UL 44 or NMX-J-451-ANCE or UL 83, UL 83A, or NMX-J-010-ANCE, or

b) Fixture-wire types rated 600 V and complying with UL 66 or NMX-J-300-ANCE.

4.1.6 Other insulated conductors

4.1.6.1 Insulated conductors other than those described in 4.1.5.2 (a) and (b) shall have insulations in thicknesses and with temperature ratings appropriate for the specific construction of Type MC cable in which they are to be used. The insulation shall be evaluated for the requested temperature rating as described in the test, Dry temperature rating of new materials (long-term aging) in UL 2556 or NMX-J-556-ANCE. Investigation of the electrical, mechanical, and physical characteristics of these insulated conductors shall show these conductors to be comparable to the conductors described in 4.1.5.2. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock, insulation resistance, and dielectric voltage-withstand.

4.1.6.2 The insulation on sector conductors shall comply with the same requirements as those for round conductors. However, due to the geometry, the average insulation thickness shall be determined using the optical micrometer method only in accordance with the test Thickness in UL 2556 or NMX-J-556-ANCE. The minimum thickness at any point shall be determined using either the optical or pin gauge method.

4.2 Optical fiber members

4.2.1 An optical-fiber member shall consist of either of the following:

a) One or more glass fibers that are individually coated and tight buffered and then:

1) Are jacketed in any thickness with one of the jacketing materials named in 4.3.7.8 or 4.3.7.9 or with another jacketing or insulating material whose applicability for the use is evaluated; or

2) Are enclosed in a nonmetallic tape, wrap, or braid that provides complete coverage and is electrically nonconductive.

b) One or more glass fibers that are individually coated, optionally tight buffered, and then enclosed with or without a gel in a loose buffer tube. A loose buffer tube:

1) Shall be of any thickness of one of the insulation or jacketing materials specified in (a);

2) Shall be enclosed in a jacket of one of these materials in any thickness; or

3) Shall be enclosed in a nonmetallic tape, wrap, or braid that provides complete coverage and is electrically nonconductive.

4.2.2 The construction of the glass fiber, of the coating, and of a tight buffer are not specified. The construction of a loose buffer tube that is covered by a jacket is not specified. The gel is not specified. The construction of a nonmetallic tape, wrap, or braid is not specified. Non-current-carrying metal or other electrically conductive parts may be included in an optical-fiber member, but an optical-fiber member shall not have any electrical elements. An optical-fiber member may include one or more strength elements.

4.3 Assembly

4.3.1 Optical-fiber member(s)

4.3.1.1 Optical-fiber member(s) alone shall not constitute a cable. One or more optical-fiber members may be included in a cable that contains 600 V conductors, but shall not be included in a cable that contains conductors rated higher than 600 V.

4.3.1.2 Each optical-fiber member shall be assembled into the cable as if it were an electrical conductor – that is, optical-fiber members shall be laid straight in a flat cable, shall be laid straight or cabled in the short round cable described in the first sentence of 4.3.2.3, and shall be cabled with the same direction and length of lay as the electrical conductors in all other round cable.

4.3.1.3 In the performance of the cable, each optical-fiber member shall be considered a filler. In a metal-clad cable, a group of optical-fiber members that does not have an electrical conductor or conductors in the group may include one or more non-current-carrying, electrically conductive parts such as a metal strength element or a metal vapor barrier. The construction of these parts is not specified. Each such part shall be physically and electrically isolated from any bare grounding conductor in the cable.

4.3.2 Circuit and grounding conductors

4.3.2.1 All of the circuit conductors and any insulated grounding conductor shall have the same temperature, wet or dry, and voltage ratings.

4.3.2.2 In a given cable, the circuit conductors shall be assembled as indicated in Table 7. Conductors with and without NEC or NOM-001-SEDE Type designations may be mixed or used alone. Sizes may be mixed within the indicated ranges. The conductors are not all required to be of the same metal. A round cable may contain precabled groups of conductors (see 4.3.2.3). Cables with interlocked aluminum armor, smooth armor, or corrugated aluminum, copper, stainless steel, or bronze armor have one or more circuit conductors. Cables with interlocked steel armor have two or more circuit conductors.

4.3.2.3 The circuit conductors in all round cables shall be cabled with a length of lay that is not greater than indicated in Table 8. The direction of lay may be changed at intervals throughout the length of the cable. The intervals are not required to be uniform.

4.3.2.4 The circuit conductors in cables intended for use in manufactured wiring systems may:

a) Be laid straight or cabled in a round cable that is not longer than 4.6 m (15 ft),

b) Consist of 600-V 3.31 mm^2 (12 AWG) copper circuit conductors with a bare or insulated 3.31 mm^2 (12 AWG) copper grounding conductor and interlocked steel or aluminum strip armor.

See required tag marking in 6.7.1(j) if the conductors are laid straight.

4.3.2.5 In a cable in which the direction of lay is reversed:

a) Each area in which the lay is right- or left-hand for not less than 5 complete twists (full 360° cycles) shall have the insulated conductors or precabled groups of insulated conductors cabled with a length of lay that is not greater than indicated in Table 8; 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 8 when determined in accordance with the test, Length of lay in UL 2556 or NMX-J-556-ANCE.

4.3.2.6 Grouping of the circuit conductors into pairs, triads, quads, and other precabled subassemblies is not required, but is acceptable if the length of lay of the conductors in each group and of the groups in the overall assembly comply with this requirement and Table 8. If the direction of lay is not reversed in a round cable containing layers of conductors or groups, the direction of lay of successive layers is not specified, but the outer layer shall have a left-hand lay. If the direction of lay is not reversed in a single-layer round cable, the conductors or groups shall have a left-hand lay.

4.3.2.7 A required grounding conductor shall be laid (cabled or straight) with the circuit conductors either as a single conductor or divided into two or more equal parts with each such part or section laid separately. Every additional grounding conductor shall be laid (cabled or straight) with the circuit conductors. Any grounding conductor may be the central conductor in a cable in which the circuit conductors are cabled, but otherwise shall not be laid straight if the conductors are cabled. Where the interlocked armor is intended as a ground path for insulated conductors with a protective covering in accordance with 4.3.7.6, the ground/bond conductor may be laid (cabled or straight) with the insulated circuit conductors. The grounding conductor in a single-conductor cable may be distributed helically around the insulated conductor with a lay length not exceeding 15 times the diameter measured over the insulated conductor when determined in accordance with the test, Length of lay in UL 2556 or NMX-J-516-ANCE. No part of a helically distributed grounding conductor in a single-conductor cable shall be smaller than 0.824 mm^2 (18 AWG).

4.3.2.8 See footnote a in Table 8 for the length of lay of the signal and/or control cables within a pre-cabled group.

4.3.3 Binders

4.3.3.1 Any group of conductors (with or without one or more optical-fiber members included in the group), or several such groups within the cable may be enclosed in a binder consisting of a shield (see 4.3.5.1 – 4.3.6.3) or of a braid, tape, or other unspecified means. An individual group or several groups may be enclosed in a thin binder jacket that complies with Table 10 for the applicable jacket material. The average thickness of a binder jacket (extruded binder) shall not be less than 0.38 mm (15 mils) when measured in accordance with the test, Average thickness – difference method in UL 2556 or NMX-J-177-ANCE.

4.3.4 Inner jacket

4.3.4.1 In any cable employing both power and/or lighting conductors and signal and/or control conductors (with or without one or more optical-fiber members included in the group) intended for use in Class 2 or 3 circuits, the group or groups of the signal and/or control conductors within the cable shall be enclosed in an inner jacket that complies with Table 10. The minimum thickness of an inner jacket shall be as shown in Table 9 when measured as described in accordance with the test, Average thickness – difference method (as applied to flexible cord jackets) in UL 2556 or NMX-J-177-ANCE.

4.3.5 Fillers

4.3.5.1 Fillers are acceptable in a cable, but are not required. Any fillers that are provided in a round cable shall be laid (cabled or straight) with the conductors.

4.3.6 Shields

4.3.6.1 A shield over an individual insulated conductor, over one or several groups of conductors with or without one or more optical-fiber members in each group, or over the entire cable assembly is optional. Several shields may be used in a given cable.

4.3.6.2 A shield shall consist of one of the following:

a) A polyester and metal laminated shield tape with or without a bare copper drain wire in electrical contact with the metal part of the tape. The drain wire shall be metal-coated if the tape metal is aluminum; otherwise, the drain wire may be metal-coated or uncoated. The drain wire may be under or over the tape;

b) A wrap or braid of metal-coated or uncoated copper wires. A braid shall not serve as a grounding conductor;

c) A metal-coated or uncoated copper tape; or

d) An evaluated equivalent of any of the above.

4.3.6.3 The details of the construction of a shield and the manner of its application are not specified, but shall be judged on the basis of the performance of the finished cable in the tests described in this Standard. The requirements for the electromagnetic performance of a shield are not specified.

4.3.7 Covering under armor

4.3.7.1 Any cable assembly that contains any bare metal component such as a grounding conductor, a metal shielding tape, or a drain wire, or is to be enclosed in an interlocked armor, shall have a covering as shown in 4.3.7.2 or a jacket as described in 4.3.7.7. The covering is optional on smooth or corrugated armored cable assemblies without bare metal components that comply with all other requirements in this Standard. The binder tape on a cable with interlocked aluminum armor intended to be used as a ground path shall enclose all elements of the assembly except the bare aluminum grounding/bonding conductor.

4.3.7.2 A covering shall consist of one of the constructions described in 4.3.7.3 – 4.3.7.6. Other constructions are acceptable if the finished cable complies with the crushing, impact, and flexibility requirements in 5.5.1, 5.5.2, and 5.10.1 – 5.10.6.

4.3.7.3 An elastomer-filled cloth or nylon tape that is frictioned on one or both sides, is of any convenient width, is at least 0.25 mm (10 mils) thick if of cloth, and 0.15 mm (6 mils) thick if of nylon when measured according to 4.3.7.7, shall be applied helically without creases or folds.

If one serving is used, the edges of the tape shall be overlapped. If two servings are used, the edges of the tape shall be abutted or overlapped in each serving. If the edges of the tape are overlapped, the lap shall be at least 3 mm (1/8 in). If two servings are used and each is overlapped, the servings may be applied in opposite directions. If two servings are used and they are applied in the same direction, the abutted or overlapped edges of the second tape shall be located approximately over the center of the tape in the underlying serving.

4.3.7.4 A treated-paper tape that is of any convenient width, is at least 12 mils (0.30 mm) thick (see 4.3.7.7 for the method of measurement), and is applied helically without creases or folds. The tape shall be applied in two or more layers with the edges of the tape abutted in each layer and all layers applied in the same direction. The abutted edges of the second and successive layers shall be located approximately over the center of the tape in the underlying layer.

4.3.7.5 A flat or corrugated polyester or polypropylene tape shall be at least 0.05 mm (2 mils) thick when measured according to 4.3.7.7. The tape shall be of any convenient width and may be applied longitudinally with or without a binder thread, or helically with a minimum 3 mm (1/8 in) lap.

4.3.7.6 A protective covering shall be applied over the individual insulated or jacketed conductors. The protective covering shall be continuous and shall have a minimum thickness of at least 0.05 mm (2 mils) and be applied either directly over the insulation or jacket layer of the individual circuit conductors and any insulated grounding conductor(s). The protective covering shall be such that the insulated conductor with the covering meets all of the mechanical, physical, electrical, and flammability requirements of the insulated conductor without the protective covering.

4.3.7.7 The thickness of any of the tapes mentioned in 4.3.7.3 – 4.3.7.5 shall be determined by measurements on a specimen removed from the finished cable. A dead-weight dial micrometer with a flat-faced circular presser foot 6.4 ±0.2 mm (0.25 ±0.01 in) in diameter and exerting 85 ±3 gf or 0.83 ±0.03 N (3.0 ±0.1 ozf) on a specimen shall be used.

4.3.7.8 A jacket (see 4.3.7.11 concerning the need for a jacket that constitutes a moisture resistant barrier) shall consist of one of the materials indicated in Table 10 (See 4.3.7.15 for the long-term evaluation of a jacket material not named in this requirement or not complying with the short-term tests specified for the material). A jacket shall not have any defects (bubbles, open spots, rips, tears, cuts, or foreign material) that are visible by inspection with normal or corrected vision without magnification. A jacket shall be applied either directly onto the assembly of circuit conductors, any grounding conductor, and any fillers or onto any (not required) skeleton braid, wrap, or tape binder over the assembly. The assembly shall be completely covered and well-centered in the jacket. Impressions of the conductors in the outer surface of the jacket shall not show depressions caused by unfilled spaces beneath the jacket. See 4.3.7.9 – 4.3.7.14.

4.3.7.9 Specimens prepared from samples of a jacket taken from the finished cable shall exhibit physical properties that are not lower than indicated in the applicable table of physical properties in as shown in Table 10.

4.3.7.10 The methods of preparing, selecting, and conditioning of specimens and of making the measurements and calculations for permanent set, ultimate elongation, and tensile strength shall be as described in the test, Physical properties (ultimate elongation and tensile strength), in UL 2556 or NMX-J-178-ANCE. Die-cut specimens shall be used.

4.3.7.11 In the case of a cable that is intended for use in wet locations and has interlocked armor over conductors insulated for use in only dry locations, a jacket resistant to moisture shall be applied under the armor. That jacket shall comply with 4.3.7.8 – 4.3.7.10 and also have a mechanical absorption of water (MWA) value that complies with 5.19. The long-term evaluation of a jacket material not identified in 5.19 or not complying with the short-term tests specified for the material shall be in accordance with 4.3.7.15.

4.3.7.12 The average thickness and the minimum thickness at any point of a jacket under interlocked, smooth, or corrugated armor shall not be less than indicated in Table 12 when determined as described in 4.3.7.13 and 4.3.7.14.

4.3.7.13 The measurements for determining the thicknesses of the jacket under the armor shall be made on a specimen of the jacket removed from the finished cable. The specimen shall be cut from the cable with its ends perpendicular to the longitudinal axis of the cable. The measurements shall be made by means of one of the following instruments:

a) A micrometer caliper that has a hemispherical surface on the anvil and on the end of the spindle and is calibrated to read directly to at least 0.01 mm (0.001 in).

b) An optical device calibrated to read directly to at least 0.01 mm (0.001 in).

4.3.7.14 Measurements shall be made at the thinnest and thickest portions of the jacket. The average of these measurements shall be taken as the average thickness of the jacket. The least of the readings shall be taken as the minimum thickness at any point of the jacket.

4.3.7.15 A jacket that is of material generically different from any jacket material covered in 4.3.7.8, 4.3.7.11, or 4.3.9.2, or that is of material covered in 4.3.7.8, 4.3.7.11, or 4.3.9.2, yet does not comply with the short-term tests specified for the material, shall be of a material and in thickness and with the temperature rating required for the specific cable construction. The material shall be evaluated for the requested temperature rating as described in the test, Dry temperature rating of new materials (long-term aging test), in UL 2556 or NMX-J-186-ANCE. Investigation of the mechanical and physical characteristics of the cable using either material shall show the material to be comparable in performance to a jacket material covered in 4.3.7.8, 4.3.7.11, or 4.3.9.2.

Note: This investigation typically includes tests such as crushing, impact, and abrasion.

4.3.7.16 Cables on which a jacket thicker than indicated in Table 12 is necessary to enable the cable to comply with any applicable flame or other test described or referenced in these requirements shall be made with whatever greater thicknesses of jacket may be needed for this purpose. Thicknesses less than those covered in Table 12 are acceptable if the finished cable employing a jacket with the reduced thicknesses complies with the tests described in this Standard. In either case, the minimum thickness at any point of the jacket shall not be less than 70 percent of the average thickness of the jacket.

Note: This investigation typically includes tests such as crushing, impact, and abrasion.

a) For a cable in which the insulation is rated for 75 – 90°C, the jacket material shall have a temperature rating that is not more than 15°C lower than the temperature rating of the insulation in the cable. The temperature rating of the cable is the same as the temperature rating of the insulation.

b) For a cable in which the insulation is rated for 150 – 200°C, the relationship between the temperature ratings of the insulation and the cable jacket is not specified, but the temperature rating of the cable is that of whichever insulation or jacket in the cable has the lowest temperature rating.

4.3.8 Armor

4.3.8.1 The cable shall be enclosed in metal armor as described in 4.3.8.2 – 4.3.8.6, and shall be applied directly over the cable assembly. On a round cable, the cross section of the armor shall be round and the armor shall consist of interlocked steel or aluminum strip, a corrugated stainless steel, aluminum-alloy, copper-alloy or bronze-alloy tube, or a smooth aluminum-alloy tube. On a flat cable, the cross section of the armor shall be rectangular (or oval) and the armor shall consist of a corrugated aluminum-alloy tube. In any case, the strip or tube shall be continuous throughout the entire length of the cable. The strip may be spliced, but there shall not be any cut or broken ends. Tube armor shall not have any weld openings, splits, or other defects.

4.3.8.2 The strip shall be made of an aluminum-base alloy with a copper content of 0.40 percent or less, or of steel. The steel strip shall be made corrosion-resistant by a coating of zinc (see 5.2) on all surfaces, including edges and splices. The coating on each surface shall be evenly distributed, shall adhere firmly at all points, and shall be smooth and free from blisters and all other defects that can diminish the protective value of the coating.

4.3.8.3 The strip shall be uniform in width, thickness, and cross section and shall not have any burrs, sharp edges, pits, scars, cracks, or other flaws that can damage the underlying or any covering elements of the cable. Splices shall not materially increase the width or thickness of the strip nor shall they lessen the mechanical strength of the strip or adversely affect the formed armor.

4.3.8.4 The thickness of the strip is to be measured before forming. Measurements are to be made by means of a micrometer caliper having an anvil and spindle that are round and are not larger than 5.1 mm (0.200 in) in diameter, with flat surfaces on each.

4.3.8.5 A stainless steel tube shall be made of stainless steel having a chromium content of not less than 16 percent.

4.3.8.6 The dimensions of aluminum or steel strip from which interlocked armor is formed, the thickness of smooth aluminum-tube armor, and the thickness and number of corrugations per unit length of corrugated stainless steel-tube, copper-tube, and aluminum-tube armor are not specified. These items are to be judged on the basis of the performance of the finished cable in the tests specified in this Standard.

4.3.9 Covering over armor

4.3.9.1 A covering is required over the interlocked, smooth, or corrugated armor of a cable that is marked for direct burial according to 6.6.1(i) or for a cable that is intended for use in wet locations as indicated in Table 7. For a dry location cable that is not marked for direct burial, a covering is acceptable over the armor but is not required.

4.3.9.2 Any covering that is over the interlocked, smooth, or corrugated armor – whether that covering is required or not – shall consist of a jacket applied directly onto the armor (see 4.3.7.14 for the long-term evaluation of a jacket material not named in this requirement or not complying with the short-term tests specified for the material). The armor shall be completely covered and well-centered in the jacket. The jacket on a round cable shall be round in cross section. The jacket on a flat cable shall be rectangular (or oval) in cross section. The outer surface of a jacket on a smooth armor shall be smooth. Impressions of the convolutions or corrugations in the outer surface of the jacket shall not show depressions caused by unfilled spaces between the convolutions or corrugations. The jacket shall comply with 4.3.9.6 and, in the case of a cable marked for direct burial according to 6.6.1(i), the cable shall additionally comply with the crushing test requirements in 5.12.

4.3.9.3 Specimens prepared from samples of the jacket taken from the finished cable shall exhibit physical properties that are not lower than indicated in Table 10 or 11 as applicable. Oil resistance at 75°C or 60°C is optional for any jacket over the armor and such jackets shall comply with the applicable oil-resistance requirements in Table 11, when tested in accordance with the test, Oil resistance, in UL 2556 or NMX-J-194-ANCE. [See also the marking requirement as specified in 6.6.1(h)]. See 4.3.7.10.

4.3.9.4 The oil in which specimens of an oil-resistant jacket shall be aged is IRM 902, which is a standard test liquid described in ASTM D471 or NMX-J-194-ANCE.

4.3.9.5 A jacket over the armor shall not be credited with providing any of the moisture resistance required in 4.3.7.11 of a jacket under interlocked armor.

4.3.9.6 The average thickness and minimum thickness at any point of a jacket over interlocked, smooth, or corrugated armor shall not be less than indicated in Table 12 when determined as described in 4.3.9.7 and 4.3.9.8.

4.3.9.7 The average thickness of the overall jacket is to be determined by the difference method, which is to consist of determining the average diameter over the jacket on the finished cable, subtracting from it the diameter of the assembly under the jacket, and dividing the result by 2. The diameters over and under the jacket are to be determined by means of a diameter tape capable of making measurements to at least 0.05 mm (0.005 in). The average thickness of the jacket is in compliance if the value determined from the diameter-tape measurements equals or exceeds the average indicated in Table 12. If the average thickness determined from the diameter-tape measurements is less than the average indicated in the table, the jacket may be removed from the cable and the average thickness determined using the following referee procedure. The thickest and thinnest portions of the jacket shall be located and measured directly with one of the micrometers specified in 4.3.9.9 (a) and (b). The average of these two micrometer measurements shall be taken as the average thickness of the jacket and shall not be less than the average indicated in Table 12.

4.3.9.8 For a flat cable, the jacket shall be removed from the cable and the thickest and thinnest portions of the jacket shall be located and measured directly with one of the micrometers specified in 4.3.9.9 (a) and (b). The average of these two micrometer measurements shall be taken as the average thickness of the jacket and shall not be less than the average indicated in Table 12.

4.3.9.9 For a round cable, the minimum thickness at any point of the overall jacket shall be determined by measuring a specimen removed from the finished cable. The specimen shall be cut from the cable with its ends perpendicular to the longitudinal axis of the cable. Measurements shall be made by means of one of the following instruments:

a) A micrometer caliper that has a flat surface on the end of the spindle and is calibrated to read directly to at least 0.01 mm (0.001 in).

b) A dead-weight dial micrometer that has a presser foot 6.4 ±0.2 mm (0.250 ±0.010 in) in diameter and exerts a total of 0.83 ±0.03 N or 85 ±3 gf (3.0 ±0.1 ozf) on the specimen - the load being applied by means of a weight. The dial micrometer is to be calibrated to read directly to at least 0.01 mm (0.001 in).

c) An optical device calibrated to read directly to at least 0.01 mm (0.001 in).

The entire surface of the spindle of the micrometer caliper or the presser foot of the dial micrometer shall be in contact with the specimen during each measurement.

5 Performance

5.1 Continuity of conductors

5.1.1 All of the circuit conductors and every grounding conductor in the finished cable shall be continuous throughout. Each 0.824 – 5.26 mm^2 (18 – 10 AWG) conductor in the finished cable shall be tested for continuity by the cable manufacturer at the cable factory.

5.1.2 Compliance with 5.1.1 shall be determined in accordance with the test, Continuity in UL 2556 or NMX-J-556-ANCE.

5.2 Test of zinc coating on steel armor

5.2.1 The coating of zinc on steel armor shall be such that all of the following requirements are met:

a) A specimen of the zinc-coated strip tested before forming shall not show a bright, adherent deposit of copper on any surface, including edges, after two 60-second immersions in a solution of copper sulphate.

b) A specimen of the partially uncoiled armor from finished cable:

1) Shall not show a bright, adherent deposit of copper after one 60-second immersion in a solution of copper sulphate; and

2) Shall not show a bright, adherent deposit of copper on more than 25 percent of any surface, including edges, after two 60-second immersions in a copper sulphate solution.

5.2.2 Compliance with 5.2.1 shall be determined in accordance with the test, Copper sulfate test for zinc coatings on formed and unformed steel strip (Preece test), in UL 2556 or the method described in NMX-H-014.

5.3 Deformation test of thermoplastic and XL jackets

5.3.1 Specimens of a thermoplastic or XL overall jacket taken from the finished cable shall not decrease in thickness by more than the percentage indicated for the jacket material in Table 13, under the load and maintained at the temperature indicated in Table 13.

5.3.2 Compliance with 5.3.1 shall be determined in accordance with the test, Deformation in UL 2556 or NMX-J-191-ANCE.

5.4 Test for tightness of armor on conductors

5.4.1 Interlocked aluminum or zinc-coated steel armor intended for use as a ground path in accordance with 4.1.2.3 and interlocked armor on a cable containing any 21.2 mm^2 (4 AWG) or larger insulated conductor(s) shall grip the cable to keep the conductor assembly from being withdrawn from a sample 3 m (10 ft) long by the application of a pull of 133 N or 13.6 kgf (30 lbf).

5.4.2 Compliance with 5.4.1 shall be determined in accordance with the test, Tightness of armor in UL 2556 or NMX-J-556-ANCE.

5.5 Flexibility test

5.5.1 Finished cable shall be capable of being wound around a circular mandrel having a diameter equal to 14 times the diameter or length of minor axis measured over the armor without damage to the armor, to the covering under the armor, or to the conductor assembly.

5.5.2 Compliance with 5.5.1 shall be determined in accordance with the test, Flexibility of armored cable and metal-sheathed cable in UL 2556 or NMX-J-556-ANCE.

5.6 Cold bend test

5.6.1 After conditioning according to 5.6.2 and 5.6.3, finished cable when examined by inspection with normal or corrected vision shall not show:

a) Any cracks, splits, or tears in any covering under or over the armor or any surface or internal cracks in any individual conductor or the conductor assembly, or

b) Any cracks, splits, tears, or other openings in smooth or corrugated armor.

Adjacent convolutions of interlocked armor may separate somewhat, but no part of the cable inside the armor shall be visible.

After being wound around a right-circular mandrel having a diameter equal to 14 times the diameter or length of minor axis measured over the outside of the finished cable.

5.6.2 Test lengths of the finished cable and a right-circular cylindrical mandrel having a diameter equal to 14 times the measured outside diameter or length of minor axis of the finished cable are to be cooled for 4 h in a circulating-air precooled chamber and maintained at a temperature of –25.0 ±2.0°C. At the end of the fourth hour and while still at the low temperature, each test length shall be bent around the mandrel for 180° without any more tension than is necessary to keep the surface of the cable in contact with the mandrel. Flat (or oval) cable is to be bent flatwise (a broad face of the cable against the mandrel).

Testing conducted outside the circulating-air chamber is optional however testing shall be completed within 15 s.

5.6.3 With a minimum of handling and flexing, each test length shall then be removed from the mandrel and the cold chamber and placed on a horizontal surface where it is to remain undisturbed for at least 4 h before being examined for surface damage and then shall be disassembled and examined further for damage.

5.7 Cold impact (optional)

5.7.1 A cable with a covering over the armor shall be considered resistant to damage at a temperature of minus 40°C if the overall jacket on at least 8 out of 10 completed cable specimens does not crack or rupture when specimens of the finished cable are subjected to impact at minus 40.0 ±2.0°C.

5.7.2 Compliance with 5.7.1 shall be determined in accordance with the test, Cold impact in UL 2556 or NMX-J-556-ANCE.

5.7.3 Cable in compliance with 5.7.1 shall be marked ″–40C″ or ″minus 40C″ on the surface in accordance with 6.6.1(l), and on the tag, reel, or carton in accordance with 6.7.1(m).

5.8 Dielectric voltage-withstand

5.8.1 Finished cable shall be capable of withstanding without breakdown the 48 — 62 Hz essentially sinusoidal rms potential indicated in Table 14 for the smallest size of insulated circuit or insulated grounding conductor in the cable. The test potential shall be applied for 60 s between the insulated conductors connected together [all of the circuit conductors and any insulated grounding conductor(s)] and the armor connected to any bare grounding conductor.

5.8.2 Compliance with 5.8.1 shall be determined in accordance with the test, Dielectric voltage-withstand in UL 2556 or NMX-J-293-ANCE.

5.9 Tension

5.9.1 Interlocked armor shall be capable of withstanding for 5 min, without opening up at any point, an axial tension imparted by a weight that exerts 667 N or 68 kgf (150 lbf).

5.9.2 The apparatus shall consist of a pair of clamps or other means (such as basket grips) that do not damage the cable, a weight that exerts 667 N or 68 kgf (150 lbf), and a secure means for suspending the weight from a support. See Figure 1.

5.9.3 The clamps shall be made of hardwood, and the two pieces comprising each clamp shall be fastened together by two bolts by means of which the armor is to be clamped tightly between the jaws without being crushed. Two clamps constructed as shown in Figure 2 are to be provided. The weight shall be equipped with a secure means for attachment to one of the clamps. A block and tackle or a differential pulley shall be used to lift the sample, clamps, and weight.

5.9.4 Three samples shall be tested. In each case, one end of a 1118-mm (44-inch) sample length of the finished cable from which any covering over the armor (see 14.1 and 14.2) has been removed shall be fastened in the clamps so that its ends project 50 mm (2 inches) beyond the edges of each clamp, thereby providing a sample 914 mm (36 inches) long between the clamps, which shall then be tightened to keep the sample from slipping.

5.9.5 The sample shall be suspended by the upper clamp with a loop of rope passing over the hook of a block and tackle or a differential pulley hung from a secure support, and the weight shall be attached to the lower clamp. The sample shall hang vertically for its full length and at right angles to the faces of the clamps. The sample, clamps, and weight shall then be raised gently so that tension is applied to the sample at a rate of not more than 890 N/min or 91 kgf/min (200 lbf/min) until the weight just clears the floor and hangs free in the air. The weight shall be kept from rotating by hand. The weight shall be supported by the sample for 5 min, is then to be let down to the floor, and the weight and clamps are to

be removed. Observation is then to be made to determine whether or not the edges of adjacent convolutions of the armor are separated to expose the interior of the cable. The cable shall be considered non-compliant if, for any of the three samples, there is exposure of the cable interior.

5.10 Impact test

5.10.1 Finished cable shall be capable of withstanding without contact between circuit conductors, and without contact between a circuit conductor and the armor and any bare or insulated grounding conductor connected together, the energy of a free-falling, flat-faced weight that impacts the cable at the point at which the cable is laid over a steel rod. Flat cable shall be capable of withstanding the impact when tested with the broad and narrow faces laid over the rod (flatwise and edgewise using separate specimens).

5.10.2 The test shall be conducted and the results evaluated as described in 5.10.3 – 5.10.11.

5.10.3 The results of testing finished cable containing three conductors that are of identical size and kind shall be considered representative of other cable constructions as indicated in Annex C.

5.10.4 A solid rectangular block of steel 121 mm (4-3/4 in) long by 76 mm (3 in) wide by 127 mm (5 in) high, with its upper face 121 by 76 mm (4-3/4 by 3 in) horizontal, shall be secured to a concrete floor, the building framework, or another solid support. A solid steel rod 19 mm (3/4 in) in diameter and 121 mm (4-3/4 in) long shall be bolted or otherwise secured to the upper face of the stationary block. The rod shall be centered on the upper face of the stationary block with the length of the rod parallel to the 121 mm (4-3/4 in) dimension of the face.

5.10.5 An impact weight of 4.54 kg (10 lb) shall be used for test samples containing 2.08 mm^2 (14 AWG) conductors, and an impact weight of 22.7 kg (50 lb) shall be used for test samples containing 33.6 mm^2 (2 AWG) conductors. In each case, the impact weight shall consist of a solid rectangular block of steel with its lower face (the face that strikes the cable) 51 mm (2 in) wide and 152 mm (6 in) long. The edges of the lower face shall be rounded to a radius of 1.5 mm (1/16 in).

5.10.6 The impact weight shall be supported with its lower face horizontal and with the longitudinal axis of its lower face in the same vertical plane as the longitudinal axes of the rod and the upper face of the stationary block. A vertical line through the centers of gravity of the impact weight, the rod, and the stationary block shall be coincident with a vertical line through the dimensional center of the lower face of the impact weight and the dimensional center of the upper face of the stationary block. A set of rails or other vertical guides shall constrain the impact weight and keep its lower face horizontal while the weight is falling and after it has struck the cable. The rails or other guides shall not interfere with the free fall of the impact weight. A means shall be provided at the top of the guides for releasing the impact weight to fall freely from any chosen height and strike the cable. A means shall also be provided to keep the weight from striking the cable more than once during each drop.

5.10.7 The test samples, the apparatus, and the surrounding air shall be in thermal equilibrium with one another at a temperature of 24.0 ±8.0°C throughout the test.

5.10.8 Round cable shall be tested in a single continuous length of at least 3.35 m (11 ft) with ten strikes being made on that length. Two such lengths shall be tested in the case of a flat (or oval) cable, with ten strikes being made flatwise (broad faces of cable contacting the impact weight and the rod) on one length and ten strikes being made edgewise (narrow faces of cable contacting the impact weight and the rod) on the other length. The points at which the cable is to be struck shall be measured and marked with chalk or by another innocuous means on the test length before the test is begun. The first mark shall be placed 305 mm (12 in) from one end of the test length and the nine remaining marks shall be made at succeeding intervals of 305 mm (12 in) down the length of the cable.

5.10.9 Each of the insulated circuit conductors in the length of cable being tested shall be connected in series with a 3-W 120-V neon lamp to one of the energized conductors of a 208-V 48 – 62 Hz 4-wire grounded-wye a-c supply circuit. The bare or insulated grounding conductor in the test length of the cable shall be connected to the armor, to all parts of the impact apparatus, to earth ground, and to the grounded supply wire.

5.10.10 The impact weight shall be secured several cable diameters above the steel rod and the cable at the first mark shall be placed and held on the steel rod with the longitudinal axis of the cable horizontal, perpendicular to the longitudinal axis of the rod, and in the vertical plane containing the coincident vertical lines mentioned in 5.10.6. The position of the 4.54-kg (10-lb) impact weight shall be adjusted to place the lower face of the weight 45.7 cm (1.5 ft) above the upper surface of the cable (this height results in an impact energy of 20.3 J or 207 kgf-cm (15 ft-lbf) for test samples containing 2.08 mm^2 (14 AWG) conductors). The position of the 22.7-kg (50–lb) impact weight shall be adjusted to place the lower face of the weight 305 mm (1 ft) above the upper surface of the cable (this height results in an impact energy of 67.8 J or 691 kgf-cm (50 ft-lbf) for test samples containing 33.6 mm^2 (2 AWG) conductors). The impact weight shall be released from this height, shall fall freely in the guides, shall strike the cable once, and shall immediately be raised up to and secured at the initial height. Note shall be taken and recorded of whether either or both of the neon lamps light during the impact indicating a momentary or other contact between the circuit conductors or between one or both of the circuit conductors and the grounding conductor, the armor, or both.

5.10.11 The test sample of the cable shall be advanced to and impacted at each of the successive marks for a total of ten strikes. The cable shall be considered noncompliant if any lamp lights at more than two of the ten impact points on any test length.

5.11 Crush resistance – all cable

5.11.1 Finished cable shall be capable of withstanding without contact between circuit conductors, and without contact between a circuit conductor and the armor and all grounding conductors connected together, the force of a flat horizontal steel plate that crushes the cable at the point at which the cable is laid over a steel rod. The results shall be evaluated as described in 5.10.3 and Annex C.

5.11.2 The cable shall be crushed between flat, horizontal steel plates in a compression machine whose jaws close at the rate of 10 ±1 mm/min (0.50 ±0.05 in/min).

5.11.3 Round cable shall be considered noncompliant if the average of the ten crushing trials is less than 4448 N (454 kgf) (1000 lbf) for a test sample containing 2.08 mm^2 (14 AWG) conductors. Round cable shall be considered noncompliant if the average of the ten crushing trials is less than 8896 N (907 kgf) (2000 lbf) for a test sample containing 33.62 mm^2 (2 AWG) conductors. Flat cable containing 2.08 mm^2 (14 AWG) conductors shall be considered noncompliant if the average of the ten crushing trials is less than 4448 N (454 kgf) (1000 lbf) for either test length. Flat cable containing 33.62 mm^2 (2 AWG) conductors shall be considered noncompliant if the average of the ten crushing trials is less than 8896 N (907 kgf) (2000 lbf) for either test length.

5.11.4 Compliance shall be determined in accordance with the test, Crush resistance, Method 2 (drill rod and plate) in UL 2556 or NMX-J-556-ANCE.

5.12 Crush resistance – cable marked for direct burial

5.12.1 Finished cable marked according to 6.6.1(i), indicating that the cable is for direct burial in accordance with 4.3.8.1, shall withstand without rupture of the overall jacket, and without rupture of the insulation on any circuit conductor or any insulated grounding conductor, a force of 4448 N (454 kgf) (1000 lbf) applied for 60 s by a flat horizontal steel plate that crushes the cable at the point at which the cable is laid over a steel rod. The test shall be conducted and the results evaluated as described in 5.12.2 – 5.12.6.

5.12.2 The results of testing finished cable containing a given number, kind(s), and size(s) of conductors (circuit and grounding) shall be considered representative of the performance of all cables containing conductors of the same kind(s) and size(s) of all cables containing the same or a larger number of the same kind(s) and size(s) of conductors of larger size(s). See 4.3.2.1, 4.3.2.2, and Table 7.

5.12.3 The cable shall be crushed between a flat, horizontal steel plate and a solid steel rod in a compression machine whose jaws close at the rate of 10 ±1 mm/min (0.50 ±0.05 in/min). Each plate shall be 50 mm (2 in) wide. A solid steel rod 19 mm (3/4 in) in diameter and of a length equal to at least 152 mm (6 in) shall be bolted or otherwise secured to the upper face of the lower plate in the compression machine. The longitudinal axes of the plates and the rod shall be in the same vertical plane. See 5.10.6.

5.12.4 Round cable shall be tested in a continuous length of at least 915 mm (36 in) with the cable being crushed at three points along that length. Two such lengths shall be tested in the case of a flat cable, with the cable being crushed flatwise (broad faces of cable contacting the flat plate and the rod) at three points on one length and edgewise (narrow faces of the cable contacting the flat plate and the rod) at three points on the other length. The points at which the cable is to be crushed shall be measured and marked with chalk or another innocuous means on the test length before the test is begun. The first mark shall be placed 230 mm (9 in) from one end of the test length and the two remaining marks shall be made at succeeding intervals down the length of the cable.

5.12.5 The upper steel plate in the compression machine shall be raised several cable diameters above the steel rod and the cable at the first mark shall be placed and held on the steel rod with the longitudinal axis of the cable horizontal, perpendicular to the longitudinal axis of the rod, and in the vertical plane that laterally bisects the plates and the rod. The upper steel plate shall be moved down until it is snug against the cable. The downward motion of the plate shall then be continued at the rate of 10 ±1 mm/min (0.50 ±0.05 in/min) increasing the force on the cable until the level indicated in 5.12.1 is reached. That level of force is to be constant for 60 s and shall then be reduced to zero by raising the upper steel plate at the rate of 10 ±1 mm/min (0.50 ±0.05 in/min) until the cable is free.

5.12.6 The length of the cable being tested shall be advanced and crushed at each of the successive marks for a total of three crushes. The overall jacket, the insulation on each circuit conductor, and the insulation on any insulated grounding conductor shall be inspected with normal or corrected vision at each of the three points at which the cable was crushed. The cable shall be considered noncompliant if the overall jacket or any of the insulation is split, torn, cracked, or otherwise ruptured at any of the three points on any of the test lengths. Cable with flattening of the overall jacket, the insulation, or both without rupture shall be considered compliant.

5.13 Fault-current test

5.13.1 The equipment-ground path provided by the metal armor and the bonding/grounding conductor in the cable described in 4.1.2.3 shall carry the specified current for the time indicated in Table 15.

5.13.2 Three samples of each cable construction of a specific equipment grounding/bonding conductor size shall be tested. Each cable shall be a minimum 610 mm (2 ft) in length and assembled to an MC cable fitting that is acceptable for grounding and for the size of cable being tested. The fitting shall be connected to an unpainted, plated or unplated, steel enclosure as shown in Figure 3 or to a steel plate simulating an enclosure as shown in Figure 4. The thickness of the enclosure or plate shall be as specified in 5.13.4 and 5.13.5.

5.13.3 A fitting locknut shall be hand-tightened and then further tightened 1/4 turn with a hammer and a standard screwdriver or by an equivalent method. A copper wire lead, not less than 610 mm (2 ft) long, shall be connected:

a) To the enclosure by a pressure wire connector; and

b) To the cable, 6.4 – 12.7 mm (1/4 – 1/2 in) from the fitting, by a ground clamp; or equivalent, of the appropriate size.

Pressure wire connectors shall be tightened using the torque specified in UL 486A-486B or NMX-J-543-ANCE. The test current shall be passed through the wire and assembly.

5.13.4 For cable constructions with a 13.3 mm^2 (6 AWG) or smaller grounding/bonding conductor, the cable and fitting assembly shall be tested with:

a) A steel enclosure or plate of thickness 1.35 – 1.40 mm (0.053 – 0.055 in) as shown in Table 15; and

b) A steel enclosure or plate of thickness 0.66 – 0.71 mm (0.026 – 0.028 in) at 470 amperes for 4 s.

Exception: The assembly shall be tested with only a steel enclosure or plate of 0.66 – 0.71 mm (0.026 – 0.028 in) thickness provided that it is tested according to Table 15.

5.13.5 The cable shall be considered noncompliant if the bonding/grounding conductor or the interlocked armor strip melt or otherwise open the circuit during the 4 s of current flow.

5.13.6 After having carried the test current, continuity shall exist between the parts of the test assembly when measured between a point on the cable and a point on the enclosure 6.4 mm (1/4 in) from the fitting. An indicating device, such as an ohmmeter or battery-and-buzzer combination, shall be used to determine whether continuity exists.

5.14 Overload current tests

5.14.1 The insulation itself and any nylon jacket or other individual covering over the insulation on the circuit conductors in finished cable containing three insulated circuit conductors of identical size and construction shall be capable of withstanding the following two overload currents without melting, rupturing, or flaming:

a) 200 percent of the ampacity of the circuit conductors for 8 min.

b) 600 percent of the ampacity of the circuit conductors for 30 s.

Also, the circuit conductors shall not adhere to one another and, when the circuit conductors are separated after the cables have cooled to room temperature, the insulation and any individual covering over the insulation shall not crack or tear and the insulation shall not show more than a 10 percent decrease in thickness at any point. The test shall be conducted and the results shall be evaluated as described in 5.14.2 – 5.14.5.

5.14.2 A 3.5-m (11-ft) specimen of finished cable with 152 mm (6 in) of the armor and all other coverings over the circuit conductors removed from each end shall be placed in a straight, open (open top and ends), flat-bottomed trough with side walls to retain any flaming material. The trough shall be made of soft 19-mm (3/4-in) wood, shall be lined with fire-resistant, chemically inert, and electrically nonconductive sheeting, and measured inside shall have dimensions of approximately 3.75 m (12 ft) long by 250 mm (10 in) wide by 225 mm (9 in) deep. The circuit conductors shall be connected in series by means of short jumpers at each end of the specimen. The armor and any grounding conductor shall not be in the circuit. At each end of the specimen, connections (by means of a connector intended for the purpose) shall be made between a low-voltage source of alternating or direct current and the free circuit conductor. A current of 80 percent of the ampacity of the circuit conductors shall be maintained in the circuit conductors for 60 min to preheat the cable in simulation of its operation in actual service.

5.14.3 After the 60 min of preheating, the current shall be increased to and maintained at 200 percent of the ampacity of the circuit conductors for 8 min. The current shall then be reduced to zero and the cable disconnected and given 24 h to cool to room temperature. If the cable is not left in the trough while it cools, it shall be removed from the trough in a manner that flexes the cable as little as possible (for example, by pulling the cable longitudinally out of the trough to rest on a flat, horizontal surface).

5.14.4 The preheat and overload described in 5.14.2 and 5.14.3 shall be repeated with a second specimen, but with the current after preheat increased to and maintained at 600 percent of the ampacity of the circuit conductors for 30 s.

5.14.5 The cable shall be considered noncompliant if it flames or ruptures or if the insulation or individual covering over the insulation melts during or as result of either or both of the two overloads. After the specimens have cooled to room temperature, the armor and all other coverings over the circuit conductors shall be removed and the circuit conductors separated and examined. The cable shall be considered noncompliant if, after either overload, the circuit conductors are found to adhere to one another or if the insulation or any individual covering over the insulation cracks or tears or if the insulation shows a decrease in thickness of more than 10 percent at any point.

5.15 Cable flame test (overall jacket in place)

5.15.1 Requirement

5.15.1.1 A vertical specimen of finished cable having an overall jacket [whether the jacket is required or not (see 4.3.8.1 and 4.3.8.2)]:

a) Shall not convey flame along its length, and

b) Shall not convey flame to combustible materials in its vicinity during, between, or after three 60-s applications of a standard test flame. The standard test flame shall be nominally 125 mm (5 in) high and shall produce heat at the nominal rate of 500 W (1700 Btu/h). The period between applications shall be 30 s regardless of whether flaming of the specimen ceases of its own accord within 30 s of the previous application. The test shall be conducted in accordance with 5.15.2 – 5.15.4 using one of the fuels described in 5.15.2.3 and the standard laboratory burner and calibration as specified in 5.15.2.1.

5.15.1.2 Flat cable shall comply both when specimens are tested with the test flame applied to a broad face of the cable and when separate specimens are tested with the test flame applied to a narrow face of the cable.

5.15.2 Apparatus and preparation of specimen

5.15.2.1 The test shall be conducted using the standard laboratory burner described in ASTM D5025-99. The gas flame produced by the burner is to be calibrated as described in ANSI/ASTM D5207-98.

5.15.2.2 The test shall be conducted in a draft-free chamber having an air-tight, windowed sash, door, or other means for access and viewing. Each linear interior dimension of the chamber shall be at least 610 mm (24 in). The actual dimensions shall result in an interior volume of the chamber of at least 4 m^3 (140 ft^3), including the volume of the exhaust transition. The size of the exhaust transition, if any, is not specified. At least 2 m^3 (70 ft^3) of this volume shall be above the area of the gas and specimen flames as space for the heat and smoke to accumulate and not influence the flames. The chamber volume at or below the level of the flames is not to contain obstructions to the natural flow of chamber air supplying oxygen to the flames. The chamber is to have an air-tight glove box for arm-and-hand access to the apparatus or other means for adjusting the apparatus while the access is completely closed. The interior of the chamber is to be visible without obstruction while the access is closed. The chamber is to be fitted with an exhaust blower for pulling smoke and fumes out of the test area after the test. A tight-sealing damper is to be located between the chamber and the blower to prevent drafts while the blower is not operating. The exhaust blower is not to be operated during the test or during calibration. Immediately after each calibration and each test, the damper is to be opened and the blower is to be operated to purge the chamber of all smoke and fumes.

5.15.2.3 For referee purposes, the fuel for this test is to be technical-grade methane (at least 98.0 percent pure) having a nominal heating value of 1000 Btu (thermochemical) per cubic foot or 37.3 MJ/m^3 (8.9 kilocalories (thermochemical) per cubic meter). Otherwise, it is appropriate to use methane of a different grade, natural gas from a cylinder or a gas main, or propane. In each such case, the gas shall be of a grade that enables the test flame to be calibrated.

5.15.2.4 The burner flame shall be calibrated at least every 30 d and each time a cylinder of gas (see 5.15.2.7) or any of the equipment is changed. Where the gas used is other than the grade of methane specified for referee purposes, the burner flame shall be calibrated each day immediately before testing begins.

5.15.2.5 This test shall be performed on unaged specimens. The specimens, the apparatus, and the surrounding air shall be in thermal equilibrium with one another at a temperature of 25.0 ±10°C or throughout the test.

5.15.2.6 The test shall be conducted in the draft-free chamber described in 5.15.2.2. The burner mounted on the wedge is to be placed directly on the floor of the chamber or, for ease of testing, on a bench within the chamber. The testing surface (chamber floor or bench top) shall be placed 1200 mm (4 ft) below the top of the chamber walls (at the transition to the exhaust). The dimensions of the testing surface of the bench shall accommodate the rectangular layer of cotton described below. A specimen 455 mm (18 in) long cut from a straight sample length of the finished cord, wire, cable, or cord conductor shall be secured with its longitudinal axis vertical. Where required, lab stands or other supports that do not create updrafts or impede the air supply to the flame shall be used to hold the specimen in place. A flat, horizontal layer of dry, pure, surgical cotton not more than 6 mm (1/4 in) thick shall cover an area of the testing surface centered on the vertical axis of the test specimen, and consisting of a circle 150 – 200 mm (6 – 8 in) in diameter. Cotton shall not be on the burner or on or under the wedge.

There shall not be any openings through the layer of cotton. The upper surface of the cotton shall be 230 – 240 mm (9 – 9-1/2 in) below point B, which is the point at which the tip of the blue inner cone of the 500-W test flame touches the specimen (See Figure 5).

5.15.2.7 Before each test and while the barrel is vertical and the burner is well away from the specimen, the gas flame shall be checked to make certain that its overall height is 125 mm (4-7/8 in) and that the blue inner cone is 40 ±2 mm (1-9/16 in) high, as established during calibration. A flame that changes from blue to luminous without any change of the settings is an indication that the fuel-gas content of the cylinder is exhausted and that the denser depletion indicator material (propane, for example), which some suppliers add to their cylinders, is being burned instead. In this case, the cylinder shall be labeled as empty and returned for refilling. Where the overall flame is blue and the height of the blue inner cone is other than 40 ±2 mm (1-9/16 in) without any change of the settings, the contents of the cylinder likely are at low pressure. A gas-supply gauge pressure of 69 – 138 kPa or 690 – 1380 mbar or 700 – 1400 gf/cm^2 (10 – 20 lbf/in^2) has been found to be adequate to maintain the required flame. A cylinder shall not be used when this range of pressure is no longer sustainable at room temperature.

5.15.2.8 A wedge (typical dimensions are shown in Figure 6) to which the base of the burner shall be secured is to angle the barrel of the burner 20 degrees from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The wedge shall be positioned to place the longitudinal axis of the barrel in the vertical plane that contains the longitudinal axis of the specimen. The wedge shall also be positioned to place point A, which is the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel, 40 mm (1-9/16 in) from point B, at which the extended longitudinal axis of the barrel meets the outer surface of the specimen. Point B is the point at which the tip of the blue inner cone is to touch the center of the front of the specimen during each application of the test flame.

5.15.2.9 The burner shall be mounted on the wedge. The wedge shall be hinged as shown in Figure 6 to enable the gas flame to be repeatedly tilted away from and then returned precisely to application to the specimen. Tilting of the burner away from and toward the specimen shall be by mechanical means or by hand. The tilt away is to be against a stop (the metal plate) that results in the gas flame angling away from the specimen beyond a vertical position. The motion of the burner shall not disturb the layer of cotton on the floor of the enclosure or result in the cotton coming away from the wedge or the base of the burner.

5.15.2.10 A strip of unreinforced 98-g/m^2 (60-lb) kraft paper that is 10 mm (1/2 in) wide, at or near 0.1 mm (5 mils) thick, and is gummed on one side shall be used to make an indicator flag. The gumming shall be moistened just enough to facilitate adhesion. With the gum toward the specimen, the strip shall be wrapped around the specimen once with its lower edge 250 mm (10 in) above B, the point at which the blue inner cone shall touch the specimen. The ends of the strip shall be pasted together evenly and trimmed to result in a flag that projects 20 mm (3/4 in) from the specimen toward the rear of the draft-free chamber, with the flag in the vertical plane described in 5.15.2.9 (see Figure 5). In testing a flat specimen, the flag shall project from the center of the rear broad face of the specimen and the test flame shall be applied to the front broad face. The lower clamp or other support for the specimen shall be adjusted vertically to keep it from being any closer than 50 – 75 mm (2 – 3 in) to point B.

5.15.2.11 The burner shall be supported as indicated in 5.15.2.9 in a position tilted away from the specimen and shall then be lit. Where the burner has a pilot light, the pilot light shall be disconnected for this test.

5.15.3 Procedure

5.15.3.1 The burner shall be tilted forward into position to apply the gas flame to the specimen, kept there for 60 s, quickly tilted back to the stop to remove the flame from the specimen for 30 s, and so forth for a total of three 60-s applications of the gas flame to the specimen with 30 s between applications.

5.15.3.2 The gas flame shall be reapplied to the specimen 30 s after the previous application regardless of whether flaming of the specimen ceases of its own accord within 30 s of the previous application.

5.15.4 Results

5.15.4.1 Where any specimen shows more than 25 percent of the indicator flag burned away or charred (soot that can be removed with a cloth or the fingers, and brown scorching, are to be ignored) following three applications of flame, the cable is to be judged capable of conveying flame along its length. Where any specimen emits flaming or glowing particles or flaming drops at any time that ignite the cotton (flameless charring of the cotton is to be ignored), or continues to flame longer than 60 s after three applications of the gas flame, the cable is to be judged capable of conveying flame to combustible materials in its vicinity.

5.16 Vertical-tray flame tests on cables

5.16.1 General

5.16.1.1 The cable manufacturer shall specify either the UL test referenced in 5.16.2.1, the FT4/IEEE 1202 test referenced in 5.16.3.1, or (for limited-smoke cable) the test referenced in 5.17, Vertical-tray fire and smoke release test for jacketed cables with optional ″ST1″ marking, for cable that has an overall jacket that is marked [see 6.4.1 (g) and (h)] for use in cable trays. Cables without a jacket comply with the requirements in 5.16 and 5.17 and are not required to be tested.

5.16.2 UL test

5.16.2.1 Cable shall not exhibit cable char (as defined in the test, Vertical-tray flame tests (Method 1 – vertical tray) in UL 2556 or NMX-J-498-ANCE) that equals or exceeds a height of 244 cm (8 ft, 0 in), measured from the bottom of the tray, when sets of cable specimens are separately installed in a vertical ladder type of cable tray and are subjected to 20 min of flame as described under the test Vertical-tray flame tests (Method 1 – vertical tray) in UL 2556 or NMX-J-498-ANCE. The test specimens shall be representative of the entire size range that the manufacturer intends to produce in each construction made.

5.16.3 FT4/IEEE 1202 test

5.16.3.1 Cable shall not exhibit cable char (as defined in the test, Vertical-tray flame tests (Method 2 – FT4) in UL 2556 or NMX-J-498-ANCE) that equals or exceeds a height of 1.5 m (4 ft, 11 in), measured from the lower edge of the burner face, when sets of specimens are tested as described in the test, Vertical-tray flame tests (Method 2 – FT4) in UL 2556 or NMX-J-498-ANCE. The test specimens shall be representative of the entire size range that the manufacturer intends to produce in each construction made.

5.17 Vertical-tray fire and smoke release test for jacketed cables with optional ″ST1″ marking

5.17.1 Each cable with an outer jacket that is marked ″ST1″ in accordance with 6.6.1(k) shall comply with the acceptance criteria for smoke release and cable damage stated in the test, ST1 limited smoke, in UL 2556 or NMX-J-556-ANCE, when sets of specimens as described in 5.17.2 are subjected to either of the flame exposures.

5.17.2 Specimens shall consist of the smallest, largest, and an intermediate size of each construction made.

5.18 Sunlight-resistance test

5.18.1 Finished cable that has an overall jacket, whether the jacket is required or not (see 4.3.8.1 and 4.3.8.2), and is marked [see 6.6.1 (f)] for use in sunlight shall be considered sunlight-resistant if five conditioned specimens retain 80 percent of their initial tensile strength and ultimate elongation values after exposure to 720 h of xenon-arc when tested in accordance with the test, Weather (sunlight) resistance, in UL 2556 or NMX-J-553-ANCE.

5.19 Test for mechanical water absorption

5.19.1 The mechanical water absorption of water (MWA) of a PVC, CP, CPE, neoprene, XL, or NBR/PVC jacket that is under the armor and is intended to be resistant to moisture (see 4.3.7.11) shall not be more than 3.1 mg/cm^2 (20.0 mg/in^2) of exposed surface when specimens of the jacket from under the armor in the finished cable are tested at 70°C.

5.19.2 Compliance with 5.19.1 shall be determined in accordance with the test described in Annex D.

5.20 Test for surface print on inner and overall jackets

5.20.1 Ink printing on the outer surface of an inner or overall jacket on finished cable shall remain legible when tested according to the test, Durability of indelible-ink printing, in UL 2556 or NMX-J-556-ANCE.

6 Marking

6.1 Intervals

6.1.1 All printing on or in a finished cable shall be repeated at the following intervals throughout the entire length of the cable:

a) Markings on the outer surface of cable having an overall jacket:

1) Size shall be repeated at intervals that are not longer than a nominal 610 mm (24 in) [maximum 635 mm (25 in)].

2) The marking in 6.11.2 for identification of copper-clad aluminum shall be repeated at intervals that are not longer than 152 mm (6 in).

3) All information other than size and the identification of copper-clad aluminum shall be repeated at intervals that are not longer than 1.02 m (40 in).

b) Markings on a marker tape in cable not having an overall jacket.

Size and all other information on a marker tape shall be repeated at intervals that are not longer than a nominal 610 mm (24 in) [maximum 635 mm (25 in)].

6.2 Re-identified cable core (US only)

6.2.1 A Type TC cable, manufactured in accordance with the requirements in UL 1277 or NMX-J-300-ANCE, that also meets the requirements for the jacketed core of a Type MC cable is permitted to be armored with or without an outer jacket. The cable shall be marked as Type MC in accordance with this Standard. The surface printing on the Type TC cable shall be removed or over-printed in a contrasting color with the marking: ″TYPE MC CABLE CORE. SEE OUTER JACKET OR MARKER TAPE FOR REQUIRED MARKINGS″.

6.3 Color of insulated grounding conductor

6.3.1 An insulated grounding conductor, whether the conductor is sectioned or not, 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 6.3.2 for details on stripes. No circuit conductor in the cable shall be green or green and yellow.

6.3.2 Stripes 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 in the case of a yellow stripe(s) or a total of 15 – 70 percent of the calculated circumference of the outer surface of the finished insulated conductor in the case of white stripes, 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).

6.4 Identification of ungrounded circuit conductor(s)

6.4.1 Each ungrounded circuit conductor in the cable 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, or green.

a) One or more broken or unbroken straight or helical stripes. See 6.3.2 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.

c) Numerals, letters, words, or a combination thereof, that comply with this Standard.

6.4.2 The markings covered in 6.4.1 and 6.5.1 shall not conflict with or be confused with any of the other markings required or otherwise covered in this Standard.

6.5 Identification of grounded circuit conductor(s)

6.5.1 In a cable in which only one conductor is intended to be a grounded circuit conductor, the conductor that is intended to be grounded 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 or gray and shall have any one of the following throughout the length of the wire or cable in a color or combination of colors other than, and in contrast with, white, gray, and green (see 6.4.2):

a) One or more broken (non-continuous) or unbroken straight or helical stripes that contrast with white and gray and are not green.

b) Numbers, letters, words, or a combination thereof, that comply with this standard and are repeated at intervals no longer than 76 mm (3 in).

c) A raised tracer.

d) Straight or helical stripes in conjunction with numbers, letters, or words that refer to the corresponding ungrounded circuit conductor color and/or identification, none of which is green.

See 6.3.2 for details on stripes.

6.6 On or in the cable

6.6.1 The following information (the sequence of the items is not specified) shall appear at the intervals indicated in 6.1.1 throughout the entire length of the finished cable. Other information (see 6.7.2), where added, shall not confuse or mislead and shall not conflict with these requirements. See 6.8.1 and 6.8.2 for date marking.

a) ″Type MC″. See 6.15. The word ″Type″ is not required.

b) The maximum operating voltage of the cable (″____ volts″ or ″____ V″).

c) The information indicated in 6.7.1(c) where each insulated conductor is not marked with that information.

d) The designation ″wet locations cable″ or ″wet locs cable″ in accordance with the ratings established in Table 7. Although it is appropriate to mark cables in accordance with the ratings established in Table 7, such marking is not required.

e) The name of the cable manufacturer, that manufacturer's trade name for the product, or both, or any other appropriate distinctive marking by means of which the organization responsible for the cable is readily identifiable. Where the organization that is responsible for the product is different from the actual manufacturer, both the responsible organization and the actual manufacturer shall be identified by name or by appropriate coding such as by trade name, trademark, the assigned electrical reference number, or the assigned combination of colored marker threads. The meaning of any coded identification shall be made available by the organization responsible for the cable. It is appropriate also to identify a private labeler; the means is not specified. This identification shall be permanent. See 6.6.2, 6.6.4, and 6.6.5.

f) The designation ″sunlight resistant″ or ″sun res″ or ″SR″ for cable that has an overall jacket complying with the sunlight-resistance test requirements in 5.18.1.

g) The designation ″for CT use″ or ″for use in cable trays″:

1) For cable that has an overall jacket and that complies with the Vertical-tray flame tests on cables, 5.16.3, yet has not been tested for sunlight-resistance or does not comply with the Sunlight-resistance test, 5.18.

2) For cable that does not have an overall jacket.

h) The designation ″oil resistant I″ or ″oil res I″ or ″PR1″ for 60°C cable and ″oil resistant II″ or ″oil res II″ or ″PR2″ for 75°C cable that has an overall jacket complying with the oil-resistance requirements in 4.3.8.3.

i) The designation ″for direct burial″, ″direct burial″, or ″dir bur″ for cable that complies with 3.3, 4.3.6.1, and 4.3.7.11; complies with the crushing-test requirements in 5.12; and has an overall jacket complying with 4.3.8.1 – 4.3.9.7.

j) The supplementary letters ″-OF″ shall be added after the type letters for each cable that contains one or more optical-fiber members.

k) The designation ″ST1″ (signifying ″limited smoke″) is appropriate for the following cables (this marking is not required):

1) Cable that has an overall jacket and complies with UL 1685 or NMX-J-556-ANCE fire and smoke test requirements referenced in Vertical-tray fire and smoke release test for jacketed cables with optional ″ST1″ marking, 5.17 of this Standard.

2) For cable that does not have an overall jacket. The ″ST1″ designation, where employed, shall be added as a suffix following the type letters.

l) A cable that complies with 5.7.1 (cold impact) shall be surface marked ″–40C″ or ″minus 40C″. This marking is also required on the tag, reel, or carton – see 6.7.1(n).

m) A cable that complies with the FT4/IEEE 1202 vertical-tray flame test in accordance with the UL 1685 or NMX-J-498-ANCE and NMX-J-474-ANCE is marked ″FT4″, ″IEEE 1202″, or both. See 5.16.3.

n) In the United States, cables that comply with the requirements in UL 2225 shall be marked with the suffix ″-HL″.

o) The designation ″Armor is equipment grounding path component″ on the marker tape in and/or on any overall jacket on cables that have interlocked aluminum or zinc-coated steel armor in contact with a bare grounding/bonding conductor, with the combination intended to be used as a ground path as described in 4.1.2.3.

p) The designation ″-PCS″ for cable that has an inner jacket complying with the requirements in 4.3.4. The ″-PCS″ designation, where employed, shall be added as a suffix following the type letters.

6.6.2 One of the following means shall be used to identify the organization that is responsible for the cable [6.6.1(e)]:

a) A legibly printed marker tape or tapes located anywhere in the cable other than under the insulation.

b) Legible printing that is considered to be permanent – that is:

1) Ink printing on the jacket under or over the armor, with the printing complying with the test in 5.20.

2) Indented or embossed printing on the jacket under or over the armor. See 6.6.5.

6.6.3 The information as specified in 6.6.1 (a) – (d) and (f) – (i) shall be:

a) Entirely on one or both of the jackets, if any, under or over the armor in the form of legible ink (the test in 5.20 is not required), indented, or embossed printing.

b) Entirely on a legibly printed marker tape or tapes located anywhere in the cable other than under the insulation.

c) Partially on either or both jackets and the marker tape or tapes. The distribution and sequence are not specified.

6.6.4 If the organization responsible for the cable produces Type MC cable in more than one factory, the marking required in accordance with 6.6.1(e) shall include an identification of the factory.

6.6.5 Indented printing shall not reduce the thickness of the inner or overall jacket below the minimum acceptable at any point indicated in Table 12.

6.7 On the tag, reel, or carton

Advisory Note: *In Mexico, the official language is Spanish. Annex E provides translations in Spanish of the English markings specified in this Standard. Markings required by this Standard may be required to be provided in other languages to conform to the language requirements of the country where the product is to be used.*

6.7.1 A tag on which the following information (the sequence of the items is not specified) is indicated plainly shall be tied to every shipping length of finished cable. However, where the cable is wound on a reel or coiled in a carton, it is appropriate for the tag to be glued, tied, stapled, or otherwise attached to the reel or carton instead of to the cable, or for the tag to be eliminated and the information printed or stenciled directly onto the reel or carton. Other information (see 6.4.2), where added, shall not confuse or mislead and shall not conflict with these requirements. See 6.8.1 and 6.8.2 for date marking.

a) ″Type MC″. See 6.15.1. The word ″Type″ is not required.

b) The maximum operating voltage of the cable (″_____ volts″ or ″_____ V″).

c) The construction used:

1) For conductors that are not of a type recognized in the National Electrical Code, NFPA 70 or in NOM-001-SEDE:

i) The quantity (not required where all conductors are of the same size) and mm^2 or AWG or kcmil size of each circuit conductor.

ii) The temperature rating as ″_____°C″ or ″_____C″ or. Degrees F shall not appear in any manner other than as shown.

iii) The locations use rating ″dry″, ″wet″, or ″dry or wet″.

2) For conductors that are of a type recognized in NFPA 70 (National Electrical Code) or in NOM-001-SEDE:

i) The quantity (not required where all conductors are of the same size) and mm^2 or AWG or kcmil size of each circuit conductor.

ii) The type-letter designation with or without the word ″Type″ preceding the type letters.

d) The information as specified in 6.6.1(d).

e) The name of the cable manufacturer, that manufacturer's trade name for the cable, or both, or any other appropriate distinctive marking by means of which the organization responsible for the cable is readily identifiable. Where the organization that is responsible for the cable is different from the actual manufacturer, both the responsible organization and the actual manufacturer shall be identified by name or by appropriate coding such as by trade name, trademark, or the assigned electrical reference number. The meaning of any coded identification shall be made available by the organization responsible for the cable. It is appropriate also to identify a private labeler; the means is not specified.

f) For a cable that contains one or more optical fibers, the following statement or another statement to the same effect:

″Optical-fiber portion(s) of cable are for installation (optical and electrical functions associated) as described in Article 770 and other applicable parts of the National Electrical Code, NFPA 70 or NOM-001-SEDE.″

g) For a cable that contains one or more optical-fiber members with any individual optical-fiber member or group of such members having a metal or other electrically conductive part as described in 4.2.1 or 4.3.1.1, the following wording or other wording to the same effect:

″Optical-fiber portion(s) of cable contain non-current-carrying metal or other electrically conductive parts.″

h) For flat cable, the following wording or other wording to the same effect:

″Use only with cable connectors suitable for flat Type MC cable.″

i) For round cable constructed as described in 4.3.2.4 and shipped from the cable factory in lengths not longer than 4.6 m (15 ft) with the conductors laid straight, the following wording or other wording to the same effect (this marking is not required where the conductors are cabled):

″For use in manufactured wiring systems.″

j) For a cable that contains one or more isolated-grounding conductors, the quantity and mm^2 (AWG or kcmil) size of such conductor(s) in the following statement:

″(mm^2 (AWG or kcmil) size) isolated-grounding conductor(s) included ″.

k) For a cable that has a smooth or corrugated sheath and contains one or more additional equipment-grounding conductors, the quantity and AWG number or kcmil size of such conductor(s) in the following statement:

″(Size) additional equipment-grounding conductor(s) included″.

l) For a cable that complies with 5.7.1 (cold impact): ″– 40C″ or ″minus 40C″.

m) Cables with corrugated or smooth armor shall be marked either:

1) ″Armor is an acceptable ground path per NEC Section 250.118(10)c″ or ″Armor is an acceptable ground path per NOM-001-SEDE Section 250.118(10)c″, or

2) ″Armor and supplemental bare grounding conductor are an acceptable ground path per NEC Section 250.118(10)c″ or ″Armor and supplemental bare grounding conductor are an acceptable ground path per NOM-001-SEDE Section 250.118(10)c″.

n) Cables that are wet rated and have an overall PVC jacket may be marked ″Suitable for use in swimming pool motor circuits″.

o) The jacket temperature rating from Table 10 or from the consideration described in 4.3.7.15, in the form ″___C jkt″ or ″___C jacket″ for 90 or 75°C cable may be marked on cable on which the overall jacket has the same temperature rating (rating not required) as the cable instead of 15°C lower (temperature rating) than the cable rating.

p) Cable with interlocked aluminum or zinc-coated steel armor and bare grounding/bonding conductor in accordance with 4.1.2.3 shall be marked:

1) ″Armor and bare grounding/bonding conductor are an acceptable ground path per NEC Section 250.118(10)b. Type MC cable fittings that comply with the requirements for use as a grounding means must be used with this cable″ or

2) ″Armor and bare grounding/bonding conductor are an acceptable ground path per NOM-001-SEDE Section 250.118(10)b. Type MC cable fittings that comply with the requirements for use as a grounding means must be used with this cable″.

q) For a cable that employs both power and/or lighting conductors, and signal and/or control conductors (with or without one or more optical-fiber members included in the group), and that has an inner jacket complying with the requirements in 4.3.4, the following wording or other wording to the same effect:

″Contains power and/or lighting as well as signal and/or control conductors per NEC Section 725.136(I)(1).″

6.7.2 An insulated conductor that complies with the requirements for VW-1 or FV-2, oil-resistant, gasoline-resistant, or similar use may itself be marked ″VW-1″, ″FV-2″, ″oil res II″, or the like. Such designations applicable to one or more of the insulated conductors may also be marked on the tag, reel, or carton for the cable if they are followed by ″cdrs″, ″conds″, ″conductors″, or the like to make it clear that they apply to the conductors rather than to the overall cable – for example, ″VW-1 cdrs″, ″FV-2 c″ or ″gasoline-resistant cdrs″. Such designations shall not appear on the exterior of the cable or on any interior part of the cable (such as on a marker tape) other than on the affected conductor or conductors.

6.8 Date of manufacture

6.8.1 For cable on which the outer surface is a jacket, the date of manufacture by month and year (or in the sequence month, day, and year) shall be included among the tag, reel, or carton markings described in 6.7.1, or shall be included among the cable markings described in 6.6.1 where legible on the outer surface of the cable. The date shall be shown in plain language, not in code.

6.8.2 For cable on which the outer surface is metal, the date of manufacture by month and year (or in the sequence month, day, and year) shall be included among the tag, reel, or carton markings described in 6.7.1. The date shall be shown in plain language, not in code.

6.9 Insulated equipment-grounding conductors

6.9.1 Where one grounding conductor is provided and it is insulated, or where one insulated grounding conductor is provided in addition to a bare conductor:

a) The insulated grounding conductor shall be green or green with one or more straight or helical, broken (non-continuous) or unbroken yellow stripes. (See 6.3.2 for details on stripes);

b) The surface of the conductor insulation shall be either unmarked or marked (″equipment ground ″ or equivalent) as indicated in 6.9.4 (it is also appropriate for a number or letter or other designation to be added as in ″equipment ground 1″, ″equipment ground A″, and similar equipment); and

c) Where the insulated conductor is sectioned (as provided for in 4.1.3.5) and is marked, each section shall be identically marked. Where one unmarked insulated grounding conductor without a yellow stripe or stripes is provided in a cable having a smooth or corrugated sheath and no bare conductor, the unmarked insulated conductor is to be considered to be a supplementary grounding conductor (part of the required grounding conductor).

6.9.2 Where two grounding conductors are provided and they are insulated, or where two insulated grounding conductors are provided in addition to a bare conductor, the insulated grounding conductors shall both be green or both shall be green with one or more yellow stripes, or one shall be green and the other green with one or more yellow stripes. Yellow stripes shall be straight or helical, broken (non-continuous) or unbroken. See 6.3.2 for details on stripes. Marking is not required where one conductor is green and the other is green and yellow. Where two unmarked grounding conductors are provided in a cable having a smooth or corrugated sheath and no bare conductor, the unmarked green conductor without a yellow stripe or stripes is to be considered to be a supplementary grounding conductor (part of the required grounding conductor). Where both conductors are green or both are green and yellow, the insulated grounding conductors shall be differentiated as follows:

a) NO BARE CONDUCTOR IN CABLE – Where one insulated grounding conductor is unmarked the other insulated grounding conductor shall be marked ″equipment ground″ or equivalent as indicated in 6.9.4. Where both insulated grounding conductors are marked, they shall be marked (″equipment ground″ or equivalent) as indicated in 6.9.4 with the number ″1″ or

the letter ″A″ or another initial designation of a series added on one conductor and the number ″2″ or the letter ″B″ or another second designation of a series added on the other conductor. If one of the two grounding conductors provided in a cable having a smooth or corrugated sheath and no bare conductor is unmarked and without a yellow stripe or stripes, the unmarked conductor is to be considered to be a supplementary grounding conductor (part of the required grounding conductor).

b) BARE CONDUCTOR INCLUDED IN CABLE – Where one insulated grounding conductor is unmarked the other insulated grounding conductor shall be marked ″equipment ground″ or equivalent as indicated in 6.9.4. Where both insulated grounding conductors are marked, they shall be marked (″equipment ground″ or equivalent) as indicated in 6.9.4 and, counting the bare conductor as the first grounding conductor, the insulated grounding conductors shall be marked as ″equipment ground 2″ and ″equipment ground 3″ or equivalent, ″equipment ground B″ and ″equipment ground C″ or equivalent, or otherwise as the second and third conductors of a series. The number ″1″, the letter ″A″, or any other initial designation of a series shall not be used.

6.9.3 Where more than two insulated grounding conductors are provided in the cable, they shall be identified and differentiated as indicated in 6.9.4 – 6.9.6.

6.9.4 Each insulated equipment-grounding conductor that is marked (see 4.1.3.1, 4.1.3.4, and 4.1.3.5) shall be marked ″equipment ground″ on its outer surface as specified in this section. The word ″equipment″ shall not be abbreviated however, it is appropriate to substitute ″grounding″, ″gnd″, or ″gndg″ for ″ground″. It is also appropriate to add the word ″conductor″ or the abbreviation ″cdr″, ″cndr″, ″condr″, ″cond″ or ″c″.

6.9.5 Where more than one insulated equipment-grounding conductor is surface-marked, each marked equipment-grounding conductor is to be differentiated from the other marked equipment-grounding conductor(s) by a number, letter, or other distinctive designation of a series – for example, ″equipment ground 1″, ″equipment ground 2, and so forth in sequence. Where the cable contains surface-marked green conductors both with and without one or more straight or helical, broken (non-continuous) or unbroken yellow stripes, (see 6.3.2 for details on stripes), the designations on each shall be of a different type – for example, numbers on one and letters on the other as in ″equipment ground 1″, ″equipment ground 2″, etc. on the green conductors and ″equipment ground A″, ″equipment ground B″, etc. on the green and yellow conductors. Numbered (or lettered or otherwise designated) equipment-grounding conductors are appropriate in a cable containing identically designated isolated-grounding conductors – for example, ″equipment ground 1″, ″equipment ground 2″, ″isolated grounding conductor 1″, and ″isolated grounding conductor 2″ in the same cable (see the final sentence of 6.10.2).

6.9.6 Where the cable contains one or more surface-marked insulated equipment-grounding conductors in addition to:

a) One unmarked green conductor with or without one or more yellow stripes;

b) One unmarked green conductor plus one unmarked green conductor with one or more yellow stripes;

c) A bare conductor; or

d) (a) or (b) plus a bare conductor, the marked equipment-grounding conductors shall be designated with a sequence of numbers, letters, etc. that start above the total count of bare, unmarked, or both, equipment-grounding conductors in the cable. The intended sequencing is indicated in the following:

1) START WITH 2 OR ITS EQUIVALENT – Where there is a bare equipment-grounding conductor or a single unmarked insulated equipment-grounding conductor in the cable (count of 1), the marked conductors shall start with ″equipment ground 2″ or its equivalent. ″Equipment ground″, ″equipment ground 1″, and their equivalents shall not be used.

2) START WITH 3 OR ITS EQUIVALENT – Where there are two unmarked insulated equipment-grounding conductors in the cable without a bare conductor (count of 2), the marked conductors shall start with ″equipment ground 3″ or its equivalent. ″Equipment ground″, ″equipment ground 1″, ″equipment ground 2″, and their equivalents shall not be used.

3) START WITH 4 OR ITS EQUIVALENT – Where there are two unmarked insulated equipment-grounding conductors and a bare conductor in the cable (count of 3), the marked conductors shall start with ″equipment ground 4″ or its equivalent. ″Equipment ground″, ″equipment ground 1″, ″equipment ground 2″, ″equipment ground 3″ and their equivalents shall not be used.

Yellow stripes shall be straight or helical, broken (non-continuous) or unbroken. See 6.3.2 for details on stripes.

6.10 Isolated-grounding conductors

6.10.1 Each isolated-grounding conductor (see 4.1.3.7) shall be marked ″isolated grounding conductor″ on its outer surface. The word ″isolated″ shall not be abbreviated however the following substitutions are appropriate: ″ground″, ″gnd″, or ″gndg″ for the word grounding, and ″cdr″, ″cndr″, ″condr″, ″cond″, or ″c″ for the word conductor.

6.10.2 Where more than one isolated-grounding conductor is used, each such conductor is to be differentiated from the other isolated-grounding conductor(s) by a number, letter, or other distinctive designation of a series in the surface marking – for example, ″isolated grounding conductor 1″, ″isolated grounding conductor 2″, and so forth in sequence. Where the cable contains isolated-grounding conductors both with and without one or more yellow stripes, the designations on each shall be of a different type – for example, numbers on one and letters on the other as in ″isolated grounding conductor 1″, ″isolated grounding conductor 2″, and the like on the green conductors and ″isolated grounding conductor A″, ″isolated grounding conductor B″, and the like on the green and yellow conductors. Numbered (or lettered or otherwise designated) isolated-grounding conductors are also appropriate in a cable containing identically designated equipment-grounding conductors – for example, ″isolated grounding conductor 1″, ″isolated grounding conductor 2″, ″equipment ground 1″, and ″equipment ground 2″ in the same cable. An isolated-grounding conductor bearing the same number, letter, and the like as a marked equipment-grounding conductor in the cable are available for use as an equipment-grounding conductor by considering the two conductors to be distinguished by their respective word markings – for example, ″isolated grounding conductor 1″ and ″equipment ground 1″ are also appropriate for use as separate equipment-grounding conductors.

6.11 Copper-clad aluminum

6.11.1 In Mexico, copper-clad aluminum conductors are not recognized.

6.11.2 If a copper-clad aluminum conductor or conductors are used, the AWG or kcmil size of the conductor(s), wherever the size appears (on the tag, reel, or carton, or on or in the cable), shall be followed by one of the designations ″AL (CU-CLAD)″, ″ALUMINUM (COPPER-CLAD)″, ″CU-CLAD AL″, or ″COPPER-CLAD ALUMINUM″. Tags, reels, and cartons for cable containing a copper-clad aluminum conductor or conductors shall have the following markings:

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 'AL-CU' or 'CC-CU'″.

b) For 3.31 – 5.26 mm^2 (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.″

6.11.3 The outer surface of the insulation or covering over the insulation on each insulated copper-clad aluminum conductor in a cable in which there are any conductors that are not of copper-clad aluminum shall be durably and legibly ink printed, indent printed, or embossed at 152 mm (6 in) or shorter intervals throughout the entire length of the cable with one of the designations ″AL (CU-CLAD)″, ″ALUMINUM (COPPER-CLAD)″, ″CU-CLAD AL″, or ″COPPER-CLAD ALUMINUM″.

6.12 Aluminum

6.12.1 If an aluminum conductor or conductors are used, the mm^2 (AWG or kcmil) size of the conductor(s), wherever the size appears (on the tag, reel, or carton, or on or in the cable), shall be followed by the word ″aluminum″ or the abbreviation ″AL″.

6.12.2 The outer surface of the insulation or covering over the insulation on each insulated aluminum conductor in a cable in which there are any conductors that are not of aluminum shall be durably and legibly ink printed, indent printed, or embossed throughout the entire length of the cable with the word ″aluminum″ or the abbreviation ″AL″.

6.13 Compact-stranded copper conductors

6.13.1 When a round compact-stranded copper conductor is used, the mm^2 (AWG or kcmil) size of the conductor – wherever the size appears (on the tag, reel, carton, or on or in the cable) – shall be followed by ″COMPACT COPPER″, ″COMPACT CU″, ″CMPCT COPPER″, or ″CMPCT CU″. Tags, reels, and cartons for compact-stranded copper conductors shall have the following marking: ″Terminate with connectors identified for use with compact-stranded copper conductors″.

6.13.2 When a compact-stranded, sector conductor is used, the same markings are required as for round compact-stranded copper conductors in 6.13.1, except that the word ″SECTOR″ shall be added immediately before ″COPPER″ or ″CU″ in each case.

6.14 Responsibility for the insulated conductors

6.14.1 No identification needed

6.14.1.1 If the insulated conductors are made by or for the organization responsible for the cable in the same factory in which the cable is made, and if the organization responsible for the cable operates no other factory in which these conductors are made, no identification need be provided in or on any length of insulated conductor in a finished cable to mark the insulated conductor as the product of a particular organization or factory.

6.14.2 Only factory identification needed

6.14.2.1 If the organization responsible for the cable operates more than one factory in which the insulated conductors are made for the acceptable Type MC cables made by or for the organization responsible for the cable, a durable and distinctive identification shall be provided in or on every length of insulated conductor in all of the organization's acceptable Type MC cables to mark the insulated conductors as the product of a particular factory unless the conductors are made in the same factory in which the cable is made. The organization is not required to be identified.

6.14.3 Organization and factory identification needed

6.14.3.1 If the insulated conductors are made by or for an organization other than the organization responsible for the cable, a permanent and distinctive identification shall be provided on or in every length of insulated conductor in a finished cable to mark the insulated conductor as the product of a particular organization and factory.

6.15 Dual marking

6.15.1 No designation shall appear on or in Type MC cable or on the tag, reel, or carton for Type MC cable indicating acceptability of the cable for use as either or both of the following (see 6.2.1 regarding use and marking of Type TC cable as the jacketed core of a Type MC cable):

a) Type TC power and control tray cable.

b) Type MV medium-voltage cable, unless also in compliance with UL 1072 or NMX-J-142/1-ANCE. See 1.3.

6.16 Installation instructions

6.16.1 Cable with interlocked aluminum or zinc-coated steel armor and bare grounding/bonding conductor in accordance with 4.1.2.3 shall have installation instructions provided with each coil or reel of cable shipped from the factory. The installation instructions shall include, but are not limited to the following information:

a) Methods of terminating the bare aluminum grounding/bonding conductor:

1) Bare aluminum grounding / bonding conductor cut off at the armor.

2) Bare aluminum grounding / bonding conductor terminated by means of a connector that complies with the requirements for use with solid aluminum conductors.

b) Fitting selection and installation.

Table 1
Conductor types
(See 4.1.5.2.1)

Type(s)	Ratings for Type MC application	UL Standard
FEP	200°C dry 600 V special applications or 90°C dry 600 V	UL 83A
RHH	90°C dry 600 V or 2 kV	UL 44 or NMX-J-451-ANCE
SA	200°C dry 600 V special applications or 90°C dry 600 V	UL 44 or NMX-J-451-ANCE
RHW-2	90°C wet or dry 600 V or 2 kV	UL 44 or NMX-J-451-ANCE
RHW	75°C wet or dry 600 V or 2 kV	UL 44 or NMX-J-451-ANCE
RHH / RHW	90°C dry 75°C wet 600 V or 2 kV	UL 44 or NMX-J-451-ANCE
XHHW-2	90°C wet or dry 600 V	UL 44 or NMX-J-451-ANCE
XHHW	90°C dry 75°C wet 600 V	UL 44 or NMX-J-451-ANCE
XHH	90°C dry 600 V	UL 44 or NMX-J-451-ANCE
THHN	90°C dry 600 V	UL 83 or NMX-J-010-ANCE
THWN-2	90°C wet or dry 600 V	UL 83 or NMX-J-010-ANCE

Table 1 Continued on Next Page

Table 1 Continued

Type(s)	Ratings for Type MC application	UL Standard
THW	75°C wet or dry 600 V	UL 83 or NMX-J-010-ANCE
THW-2	90°C wet or dry 600 V	UL 83 or NMX-J-010-ANCE
THHW	90°C dry 75°C wet 600 V	UL 83 or NMX-J-010-ANCE
THWN	75°C wet or dry 600 V	UL 83 or NMX-J-010-ANCE
THHN / THWN	90°C dry 75°C wet 600 V	UL 83 or NMX-J-010-ANCE
Z	150°C dry 600 V special applications or 90°C dry 600 V	UL 83A
ZW	150°C dry 600 V special applications or 75°C wet 90°C dry 600 V	UL 83A

Table 2
Fixture wire or control conductor types

(See 4.1.5.2.1)

Type(s)	Ratings for Type MC application	Size range
PF and PGF	200°C dry 600 V	0.824 – 2.08 mm^2 (18 – 14 AWG)
PFF and PGFF	150°C dry 600 V	0.824 – 2.08 mm^2 (18 – 14 AWG)
SF-2	90°C dry 600 V	0.824 – 2.08 mm^2 (18 – 14 AWG)
SFF-2	90°C dry 600 V	0.824 – 2.08 mm^2 (18 – 14 AWG)
TFN	90°C dry 600 V	0.824 – 1.31 mm^2 (18 – 16 AWG)
TFFN	90°C dry 600 V	0.824 – 1.31 mm^2 (18 – 16 AWG)
RFH-2	75°C dry 600 V	0.824 – 1.31 mm^2 (18 – 16 AWG)
FFH-2	75°C dry 600 V	0.824 – 1.31 mm^2 (18 – 16 AWG)

Table 3
Smallest acceptable grounding conductor in cable containing 90°C circuit conductors

(See 4.1.3.1, 4.1.3.2, 4.1.3.3 and 4.1.3.4)

Size of largest ungrounded circuit conductor [mm² (AWG or kcmil)]		Grounding conductor		Maximum acceptable DC resistance of ground path[a]			
		Copper	Aluminum or copper-clad aluminum	20°C		25°C	
Copper	Aluminum or copper-clad aluminum	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Ω·km of armor	(Ω·1000 ft of armor)	Ω·km of armor	(Ω·1000 ft of armor)
0.824 mm² (18 AWG)	–	0.824 (18)	–	23.2	(7.06)	23.6	(7.19)
1.04 (17)	–	1.04 (17)	–	18.3	(5.59)	18.7	(5.70)
1.31 (16)	–	1.31 (16)	–	14.6	(4.45)	14.9	(4.53)
1.65 (15)	–	1.65 (15)	–	11.3	(3.44)	11.5	(3.51)
2.08 (14)	3.31 (12 AWG)	2.08 (14)	3.31 (12)	8.96	(2.73)	9.14	(2.78)
2.63 (13)	4.17 (11)	2.63 (13)	4.17 (11)	7.10	(2.16)	7.24	(2.20)
3.31 (12)	5.26 (10)	3.31 (12)	5.26 (10)	5.64	(1.72)	5.75	(1.75)
4.17 (11)	6.63 (9)	4.17 (11)	6.63 (9)	4.48	(1.37)	4.56	(1.39)
5.26 – 8.37 (10 – 8)	8.37 – 13.3 (8 – 6)	5.26 (10)	8.37 (8)	3.546	(1.080)	3.615	(1.102)
10.6 – 21.2 (7 – 4)	16.8 – 33.6 (5 – 2)	8.37 (8)	13.3 (6)	2.230	(0.6795)	2.274	(0.6929)
26.7 – 67.4 (3 – 2/0)	42.4 – 85.0 (1 – 3/0)	13.3 (6)	21.2 (4)	1.403	(0.4276)	1.430	(0.4359)
85.0 – 127 (3/0 AWG – 250 kcmil)	107.2 – 177 (4/0 AWG – 350 kcmil)	21.2 (4)	33.6 (2)	0.8820	(0.2689)	0.8993	(0.2742)
152 – 203 (300 – 400)	203 – 304 (400 – 600)	26.7 (3)	42.4 (1)	0.6996	(0.2132)	0.7133	(0.2175)
228 – 329 (450 – 650)	355 – 507 (700 – 1000)	33.6 (2)	53.5 (1/0)	0.5548	(0.1691)	0.5657	(0.1724)
355 – 456 (700 – 900)	557 – 760 (1100 – 1500)	42.4 (1)	67.4 (2/0)	0.4398	(0.1340)	0.4485	(0.1367)
507 – 1010 (1000 – 2000)	811 – 1010 (1600 – 2000)	53.5 (1/0)	85.0 (3/0)	0.3487	(0.1063)	0.3556	(0.1084)

[a] Maximum acceptable DC resistance (1) of sectioned grounding conductor, (2) of corrugated- or smooth-sheath armor in cable without a required grounding conductor, and (3) of the parallel combination of required grounding conductor and armor in cable having corrugated- or smooth-sheath armor of higher resistance than indicated in the columns.

Table 4
Smallest acceptable grounding conductor in cable containing 75°C circuit conductors

(See 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.1.3.4, and 4.1.3.5)

Size of largest ungrounded circuit conductor [mm² (AWG or kcmil)]		Grounding conductor		Maximum acceptable DC resistance of ground path[a]			
		Copper	Aluminum or copper-clad aluminum	20°C		25°C	
Copper	Aluminum or copper-clad aluminum	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Ω·km of armor	Ω·1000 ft of armor	Ω·km of armor	Ω·1000 ft of armor
0.824 (18 AWG)	–	0.824 (18)	–	23.2	7.06	23.6	7.19
1.04 (17)	–	1.04 (17)	–	18.3	5.59	18.7	5.70
1.31 (16)	–	1.31 (16)	–	14.6	4.45	14.9	4.53
1.65 (15)	–	1.65 (15)	–	11.3	3.44	11.5	3.51
2.08 (14)	3.31 (12 AWG)	2.08 (14)	3.31 (12)	8.96	2.73	9.14	2.78
2.63 (13)	4.17 (11)	2.63 (13)	4.17 (11)	7.10	2.16	7.24	2.20
3.31 (12)	5.26 (10)	3.31 (12)	5.26 (10)	5.64	1.72	5.75	1.75
4.17 (11)	6.63 (9)	4.17 (11)	6.63 (9)	4.48	1.37	4.56	1.39
5.26 – 10.6 (10 – 7)	8.37 – 16.8 (8 – 5)	5.26 (10)	8.37 (8)	3.546	1.080	3.615	1.102
13.3 – 26.7 (6 – 3)	21.2 – 42.4 (4 – 1)	8.37 (8)	13.3 (6)	2.230	0.6795	2.274	0.6929
33.6 – 85.0 (2 – 3/0)	53.5 – 107.2 (1/0 – 4/0)	13.3 (6)	21.2 (4)	1.403	0.4276	1.430	0.4359
107.2 – 152 (4/0 AWG – 300 kcmil)	127 – 228 (250 – 450 kcmil)	21.2 (4)	33.6 (2)	0.8820	0.2689	0.8993	0.2742
177 – 279 (350 – 550)	253 – 405 (500 – 800)	26.7 (3)	42.4 (1)	0.6996	0.2132	0.7133	0.2175
304 – 405 (600 – 800)	456 – 659 (900 – 1300)	33.6 (2)	53.5 (1/0)	0.5548	0.1691	0.5657	0.1724
456 – 659 (900 – 1300)	709 – 1010 (1400 – 2000)	42.4 (1)	67.4 (2/0)	0.4398	0.1340	0.4485	0.1367
709 – 1010 (1400 – 2000)	–	53.5 (1/0)	85.0 (3/0)	0.3487	0.1063	0.3556	0.1084

[a] Maximum acceptable DC resistance (1) of sectioned grounding conductor, (2) of corrugated- or smooth-sheath armor in cable without a required grounding conductor, and (3) of the parallel combination of required grounding conductor and armor in cable having corrugated- or smooth-sheath armor of higher resistance than indicated in the columns.

Table 5
Smallest acceptable grounding conductor in cable containing one 90°C circuit conductor

(See 4.1.2.1)

Size of the circuit conductor [mm² (AWG or kcmil)]		Grounding conductor		Maximum acceptable DC resistance of ground path[a]			
		Copper	Aluminum or copper-clad aluminum	20°C		25°C	
Copper	Aluminum or copper-clad aluminum	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Ω·km of armor	(Ω·1000 ft of armor)	Ω·km of armor	(Ω·1000 ft of armor)
3.31 (12 AWG)	5.26 (10 AWG)	3.31 (12)	5.26 (10)	5.64	1.72	5.75	1.75
4.17 (11)	6.63 (9)	4.17 (11)	6.63 (9)	4.48	1.37	4.56	1.39
5.26 (10)	8.37 (8)	5.26 (10)	8.37 (8)	3.546	1.080	3.615	1.102
8.37 (8)	13.3 (6)	8.37 (8)	13.3 (6)	2.230	0.6795	2.274	0.6929
13.3 – 33.6 (6 – 2)	21.2 – 42.4 (4 – 1)	13.3 (6)	21.2 (4)	1.403	0.4276	1.430	0.4359
42.4 – 67.4 (1 – 2/0)	53.5 – 85.0 (1/0 – 3/0)	21.2 (4)	33.6 (2)	0.8820	0.2689	0.8993	0.2742
85.0 (3/0)	107.2 – 152 (4/0 AWG – 300 kcmil)	26.7 (3)	42.4 (1)	0.6996	0.2132	0.7133	0.2175
107.2 – 152 (4/0 AWG – 250 kcmil)	177 – 228 (350 – 400)	33.6 (2)	53.5 (1/0)	0.5548	0.1691	0.5657	0.1724
152 – 177 (300 – 350)	253 (500)	42.4 (1)	67.4 (2/0)	0.4398	0.1340	0.4485	0.1367
203 – 304 (400 – 600)	304 – 456 (600 – 900)	53.5 (1/0)	85.0 (3/0)	0.3487	0.1063	0.3556	0.1084
355 – 456 (700 – 900)	507 (1000)	67.4 (2/0)	107.2 (4/0)	0.2766	0.08432	0.2820	0.08598
507 (1000)	–	85.0 (3/0)	–	0.2194	0.0668	0.2238	0.06820

[a] Maximum acceptable DC resistance (1) of sectioned grounding conductor, (2) of corrugated- or smooth-sheath armor in cable without a required grounding conductor and (3) of the parallel combination of required grounding conductor and armor in cable having corrugated- or smooth-sheath armor of higher resistance than indicated in the columns.

Table 6
Smallest acceptable grounding conductor in cable containing one 75°C circuit conductor

(See 4.1.2.1)

Size of the circuit conductor [mm² (AWG or kcmil)]		Grounding conductor		Maximum acceptable DC resistance of grounding path[a]			
		Copper	Aluminum or copper-clad aluminum	20°C		25°C	
Copper	Aluminum or copper-clad aluminum	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Smallest acceptable mm² (AWG) size of unsectioned grounding conductor	Ω·km of armor	(Ω·1000 ft of armor)	Ω·km of armor	(Ω·1000 ft of armor)
3.31 (12 AWG)	5.26 (10 AWG)	3.31 (12)	5.26 (10)	5.64	(1.72)	5.75	(1.75)
4.17 (11)	6.63 (9)	4.17 (11)	6.63 (9)	4.48	(1.37)	4.56	(1.39)
5.26 – 10.6 (10 – 7)	8.37 (8)	5.26 (10)	8.37 (8)	3.546	(1.080)	3.615	(1.102)
13.3 (6)	13.3 – 21.2 (6 – 4)	8.37 (8)	13.3 (6)	2.230	(0.6795)	2.274	(0.6929)
21.2 – 33.6 (4 – 1)	26.7 – 53.5 (3 – 1/0)	13.3 (6)	21.2 (4)	1.403	(0.4276)	1.430	(0.4359)
53.5 – 67.4 (1/0 – 2/0)	67.4 – 107.2 (2/0 – 4/0)	21.2 (4)	33.6 (2)	0.8820	(0.2689)	0.8993	(0.2742)
85.0 – 107.2 (3/0 – 4/0)	127 – 177 (250 – 350 kcmil)	26.7 (3)	42.4 (1)	0.6996	(0.2132)	0.7133	(0.2175)
127 – 152 (250 – 300 kcmil)	203 – 253 (400 – 500)	33.6 (2)	53.5 (1/0)	0.5548	(0.1691)	0.5657	(0.1724)
177 – 203 (350 – 400)	304 – 355 (600 – 700)	42.4 (1)	67.4 (2/0)	0.4398	(0.1340)	0.4485	(0.1367)
253 – 355 (500 – 750)	380 – 507 (750 – 1000)	53.5 (1/0)	85.0 (3/0)	0.3487	(0.1063)	0.3556	(0.1084)
405 – 507 (800 – 1000)	–	67.4 (2/0)	–	0.2766	(0.08432)	0.2820	(0.08598)

[a] Maximum acceptable DC resistance (1) of sectioned grounding conductor, (2) of corrugated- or smooth-sheath armor in cable without a required grounding conductor and (3) of the parallel combination of required grounding conductor and armor in cable having corrugated- or smooth-sheath armor of higher resistance than indicated in the columns.

Table 7
Assembly of conductors and wet or dry rating

(See 4.1.2.1)

Construction over conductor assembly			Conductor rating	Wet or dry locations rating of cable
Armor	Jacket			
	Under armor	Over armor		
Interlocked	No	No	Dry or wet	Dry
	No	Yes	Dry	Dry
	No	Yes	Wet	Dry or wet
	Yes	Yes	Dry or wet	Dry or wet
Smooth or corrugated	Yes or No	Yes	Dry or wet	Dry or wet

Table 8
Length of lay of insulated conductors and pre-cabled groups in a round cable[a]

(See 4.3.2.3)

Number of insulated conductors in a cable not containing groups of insulated conductors or number of insulated conductors in a group or number of groups in a cable containing groups of insulated conductors	Maximum acceptable length of lay
2	30 times conductor or group diameter[b]
3	35 times conductor or group diameter[b]
4	40 times conductor or group diameter[b]
5 or more	15 times the calculated overall diameter of the group or overall assembly, but in a multiple-layer cable, the length of lay of the conductors or group in each of the inner layers is not specified (governed by the construction of the cabling machine)

[a] The length of lay of the signal and/or control cables within a pre-cabled group per 4.3.2.7 consisting of 12 or fewer twisted pairs or 2, 3, or 4 single insulated conductors are permitted to have the pairs or insulated conductors laid straight. For all other constructions the length of lay is not specified.

[b] "Conductors or group diameter" is the calculated diameter over the largest individual, finished circuit conductor or group of conductors in the cable.

Table 9
Thickness of inner jacket

(See 4.3.4.1)

Calculated diameter of round assembly under inner jacket or calculated length of major axis of flat assembly under inner jacket		Minimum average thickness		Minimum thickness at any point	
mm	(in)	mm	(mils)	mm	(mils)
0 – 17.78	(0 – 0.700)	0.76	(30)	0.61	(24)
Over 17.78, but not over 38.10	(Over 0.700, but not over 1.500)	1.14	(45)	0.91	(36)
Over 38.10, but not over 63.50	(Over 1.500, but not over 2.500)	1.52	(60)	1.22	(48)

Table 10
Physical properties of jacket under or over armor

[See 4.3.3.1, 4.3.4.1, 4.3.7.8, 4.3.7.9, 4.3.9.3, 6.7.1(o)]

Material(s)	Temperature rating of jacket	Condition of specimens at time of measurement	Maximum set in recovery test [25 mm (1 in) bench marks stretched to 75 mm (3 in)]	Minimum ultimate elongation (25 mm (1 in) bench marks unless otherwise specified)	Minimum tensile strength
CP	90°C	Unaged	–	200 percent	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C	–	50 percent of the result of unaged specimens	85 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	–	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
	75°C	Unaged	–	200 percent	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C	–	50 percent of the result of unaged specimens	85 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	–	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
	60°C	Unaged	25 percent [6.2 mm (0.25 in)]	300 percent [75 mm (3 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C	Not measured	70 percent of the result of unaged specimens	70 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	Not measured	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
Thermoplastic CPE	90°C	Unaged	–	150 percent [75 mm (3 in)]	9.65 MPa (1400 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 120.0 ±1.0°C	–	50 percent of the result of unaged specimens	85 percent of the result of unaged specimens
Thermoset CPE	90°C	Unaged	–	250 percent [62.5 mm (2.5 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C	–	60 percent of the result of unaged specimens	85 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	–	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
	75°C	Unaged	–	200 percent [62.5 mm (2.5 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C	–	60 percent of the result of unaged specimens	85 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	–	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens

Table 10 Continued on Next Page

Table 10 Continued

Material(s)	Temperature rating of jacket	Condition of specimens at time of measurement	Maximum set in recovery test [25 mm (1 in) bench marks stretched to 75 mm (3 in)]	Minimum ultimate elongation (25 mm (1 in) bench marks unless otherwise specified)	Minimum tensile strength
ETFE and ECTFE	150°C	Unaged		100 percent [50 mm (2 in)] Tested at a speed of 50 ±5 mm/s (2 ±0.2 in/s), with band marking inks in place or removed prior to aging of specimens	34.5 MPa (5000 lbf/in^2) Tested at a speed of 50 ± 5 mm/s (2 ± 0.2 in/s), with band marking inks in place or removed prior to aging of specimens
NBR/PVC	90°C	Unaged	31 percent [7.8 mm (0.31 in)]	250 percent [62.5 mm (2.5 in)]	8.27 MPa (1200 lbf/in^2)
		Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C	Not measured	50 percent [(12.5 mm (0.5 in)]	6.21 MPa (900 lbf/in^2)
		Aged in oil for 18 h at 121.0 ±1.0°C	Not measured	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
	75°C	Unaged	–	200 percent [(62.5 mm (2.5 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C	–	50 percent of the result of unaged specimens	70 percent of the result of unaged specimens
		Aged in oil for 18 h at 121.0 ±1.0°C	–	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
Neoprene	90°C	Unaged	25 percent [6.2 mm (0.25 in)]	250 percent [62.5 mm (2.5 in)]	8.27 MPa (1200 lbf/in^2)
		Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C	Not measured	50 percent [12.5 mm (0.5 in)]	6.21 MPa (900 lbf/in^2)
		Aged in oil for 18 h at 121.0 ±1.0°C	Not measured	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens
	75°C	Unaged	19 percent [4.8 mm (0.19 in)]	300 percent [75 mm (3 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C	Not measured	50 percent of the result of unaged specimens	70 percent of the result of unaged specimens
		60°C oil-resistant insulation Aged in oil for 18 h at 121.0 ±1.0°C	Not measured	60 percent of the result of unaged specimens	60 percent of the result of unaged specimens

Table 10 Continued on Next Page

Table 10 Continued

Material(s)	Temperature rating of jacket	Condition of specimens at time of measurement	Maximum set in recovery test [25 mm (1 in) bench marks stretched to 75 mm (3 in)]	Minimum ultimate elongation (25 mm (1 in) bench marks unless otherwise specified)	Minimum tensile strength
PVC	90°C	Unaged	–	100 percent [25 mm (1 in)]	10.3 MPa (1500 lbf/in^2)
	50.182	Aged in a full-draft circulating-air oven for 168 h at 121 ±1.0°C	–	45 percent of the result with unaged die-cut specimens 65 percent of the result with all other unaged specimens	70 percent of the result with unaged die-cut specimens 70 percent of the result with all other unaged specimens
	75°C	Unaged	–	100 percent [25 mm (1 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 240 h at 100 ±1.0°C	–	45 percent of the result with unaged die-cut specimens 65 percent of the result with all other unaged specimens	70 percent of the result with unaged die-cut specimens 70 percent of the result with all other unaged specimens
		75°C oil-resistant insulation Aged in oil for 60 d at 75.0 ±1.0°C	–	65 percent of the result of unaged specimens	65 percent of the result of unaged specimens
	60°C	Unaged	–	100 percent [25 mm (1 in)]	10.3 MPa (1500 lbf/in^2)
		Aged in a full-draft circulating-air oven for 168 h at 100.0 ±1.0°C	–	75 percent of the result with unaged specimens tested at the same speed	85 percent of the result with unaged specimens tested at the same speed
		60°C oil-resistant insulation Aged in oil for 18 h at 121.0 ±1.0°C	–	85 percent of the result of unaged specimens	85 percent of the result of unaged specimens
		60°C oil-resistant jacket Aged in oil for 18 h at 121.0 ±1.0°C	–	75 percent of the result of unaged specimens	75 percent of the result of unaged specimens
LDFRPE and HDFRPE	75°C	Unaged	–	100 percent [25 mm (1 in)]	8.27 MPa (1200 lbf/in^2)
		Aged in a full-draft circulating-air oven for 48 h at 100.0 ±1.0°C	–	75 percent of the result of unaged specimens	75 percent of the result of unaged specimens

Table 10 Continued on Next Page