



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 revision of ANSI/UL 1569 dated April 22, 2024 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

As noted in the Commitment for Amendments statement located on the back side of the title page, ULSE and ANCE are committed to updating this harmonized standard jointly. However, the revision pages dated April 22, 2024 will not be jointly issued by ULSE and ANCE as these revision pages only address UL ANSI approval dates.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated February 23, 2024.

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



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Fifth Edition

Metal-Clad Cables

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Commitment for Amendments

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

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This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through April 22, 2024. The most recent designation of ANSI/UL 1569 as a Reaffirmed American National Standard (ANS) occurred on April 22, 2024. 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 ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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PREFACE

This is the harmonized ANCE and ULSE 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 ULSE. 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 Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of CANAME member manufacturers and users.

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 ULSE.

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Metal-Clad Cables

1 Scope

1.1 These requirements cover round or flat metal-clad cables that contain 0.824 – 1010 mm² (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
Thermoplastic-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 mm² (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 $13.3 - 1010 \text{ mm}^2$ (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 $0.824 - 8.37 \text{ mm}^2$ (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 of the cable.

sections (see [4.1.3.6](#)) and is not smaller than indicated under the heading "Grounding Conductor" in [Table 3](#) or [Table 5](#) [90°C circuit conductors] or in [Table 4](#) or [Table 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 [Table 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 $0.824 - 13.3 \text{ mm}^2$ (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 [Table 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 [Table 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 [Table 5](#) [90°C circuit conductors] or in [Table 4](#) or [Table 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 [Table 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 [Table 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 [Table 3](#) – [Table 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 $53.5 - 380 \text{ mm}^2$ (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 [Table 2](#):

- a) $2.08 - 107 \text{ mm}^2$ (14 – 4/0 AWG) and $127 - 1010 \text{ mm}^2$ (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 mm² (12 AWG) copper circuit conductors with a bare or insulated 3.31 mm² (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 mm² (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.