



# UL 1696

## STANDARD FOR SAFETY

### Mechanical Protection Tubing (MPT) and Fittings

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UL Standard for Safety for Mechanical Protection Tubing (MPT) and Fittings, UL 1696

Third Edition, Dated March 31, 2021

### **Summary of Topics**

***This new edition of ANSI/UL 1696 includes References to the Mexican Electrical Installation Code, Reference Publications and ANCE References.***

The new requirements are substantially in accordance with Proposal(s) on this subject dated January 17, 2020 and August 14, 2020.

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Association of Standardization and Certification  
NMX-J-855-ANCE  
First Edition



CSA Group  
CSA C22.2 No. 227.3:21  
Fifth Edition



Underwriters Laboratories Inc.  
UL 1696  
Third Edition

## Standard for Mechanical Protection Tubing (MPT) and Fittings

March 31, 2021



ANSI/UL 1696-2021



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## Preface

This is the harmonized ANCE, CSA Group, and UL standard for Mechanical Protection Tubing (MPT) and Fittings. It is the first edition of NMX-J-855-ANCE, the fifth edition of CSA C22.2 No. 227.3, and the third edition of UL 1696. This edition of CSA C22.2 No. 227.3 supersedes the previous edition of CSA C22.2 No. 227.3 published on January 9, 2015. This edition of UL 1696 supersedes the second edition of UL 1696 published on January 9, 2015.

This harmonized standard was prepared by the Association of Standardization and Certification, (ANCE), CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the conduit manufacturing industry and the Technical Harmonization Committee 23A, NMPT Working Group, of the Council on the Harmonization of Electrotechnical Standards for 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 23 Electrical Accessories from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the mechanical protection tubing manufacturers and users.

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

## Application of Standard

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

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

## Level of Harmonization

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

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

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

## Reasons for Differences from IEC

The Technical Harmonization Committee determined the safe use of nonmetallic mechanical protection tubing and fittings is dependent on the design and performance of the raceway and cable systems with which they are intended to be installed. Significant investigation is required to assess safety and system compatibility issues that may lead to harmonization of traditional North American nonmetallic tubing and

fittings with those presently addressed in the known IEC standards. The THC agreed such future investigation might be facilitated by completion of harmonization of the North American standards for mechanical protection tubing and fittings.

### **Interpretations**

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

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# Mechanical Protection Tubing (MPT) and Fittings

## 1 Scope

1.1 This Standard applies to nonmetallic or composite mechanical protection tubing (MPT), and nonmetallic, composite or metallic fittings, and clamps used for the support, routing and mechanical protection of conductors, wires, and cables. The MPT, fittings, and clamps are intended to be used to interconnect separate component assemblies or consoles of electrical devices, such as robotics, medical or X-ray equipment. The mechanical protection afforded the internal wiring contained within the tubing is considered equivalent to the protection provided by a type SJT flexible cord. Mechanical protection tubing (MPT) may be submitted without fittings, clamps, etc.

1.2 The MPT, fittings, and clamps covered by this Standard are not intended for use as a wiring method in accordance with NFPA 70, National Electrical Code (NEC), CSA C22.1, Canadian Electrical Code (CE Code), Part I and NOM-001-SEDE Standard for Electrical Installations.

1.3 This Standard does not include standard trade sizes. The MPT, fittings, and clamps from different manufacturers are not interchangeable unless the combination of MPT, fittings, and clamps are determined to be in accordance with this Standard.

## 2 Normative References

2.1 Where reference is made to other publications, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this Standard was approved.

### ASTM\* Standards

ASTM D 2444

*Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*

ASTM D 5025

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

ASTM D 5207

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

ASTM D 5423

*Standard Specification for Forced – Convection Laboratory Ovens for Evaluation of Electrical Insulation*

ASTM G 155

*Standard Practice for Operating Xenon Arc Light Apparatus for Exposure for Nonmetallic Materials*

\* American Society for Testing and Materials.

### ANCE/MEXICAN Standards

NMX-J-017-ANCE

*Conduit, Tubing and cable Fittings – Specifications and Test Methods*

**NMX-J-565/3-ANCE**

*Safety requirements – Flammability of Plastic Materials for Parts in Devices and Appliances – Test Methods*

**NMX-J-417-ANCE**

*Wires and Cables – Convection Laboratory Ovens for Evaluation of Electrical Insulation – Specifications and Test Methods*

**CSA Group Standards****CSA C22.1:21**

*Canadian Electrical Code (CE Code), Part I*

**CAN/CSA-C22.2 No. 0-10 (R2015)**

*General requirements – Canadian Electrical Code, Part II*

**CAN/CSA-C22.2 No. 0.17-00 (R2018)**

*Evaluation of Properties of Polymeric Materials*

**CSA C22.2 No. 211.0-03 (R2017)**

*General Requirements and Methods of Testing for Nonmetallic Conduit*

**CSA C22.2 No. 18.3-12 (R2017)**

*Conduit, Tubing, and Cable Fittings*

**National Research Council Canada**

*National Building Code of Canada, 2010*

**UL Standards****UL 514B**

*Conduit, Tubing, and Cable Fittings*

**UL 746A**

*Polymeric Materials – Short Term Property Evaluations*

**UL 746B**

*Polymeric Materials – Long Term Property Evaluations*

**UL 94**

*Test for Flammability of Plastic Materials for Parts in Devices and Appliances*

**Secretary of Energy (Mexico)****NOM-001-SEDE**

*Standard for Electrical Installations*

**3 Definitions**

3.1 The following definitions apply in this Standard:

3.2 Clamp – An external device used to secure, but not support, MPT.

3.3 Connector – A fitting intended to terminate, secure, and support MPT to an enclosure, equipment or similar device.

3.4 Coupling – A fitting intended to securely connect two lengths of MPT.

3.5 Fitting – A device, such as a coupling or connector, that provides a means for securing MPT to an enclosure, splicing between lengths of MPT, or securing MPT to equipment that maintains the support and protection of the MPT.

3.6 Composite Fitting – A fitting constructed of both metallic, other than screws and the like, and nonmetallic materials.

Note: The presence of screws, nuts, washers and unexposed metallic sleeves for screws should not be the sole means to change the classification of a fitting from "nonmetallic" to "composite." These components generally are not likely to become energized in the event of a conductor fault so they are not subject to the test in [6.13](#) and a protective coating is not measured in accordance with [6.14.2](#).

3.7 Metallic Fitting – A fitting constructed completely of metallic materials.

3.8 Nonmetallic Fitting – A fitting constructed completely of nonmetallic materials.

Note: See note in [3.6](#).

3.9 Mechanical Protection Tubing (MPT) – An enclosed channel of nonmetallic or composite construction that is intended to be repeatedly flexed throughout its life.

3.10 Composite MPT – A tubing constructed of nonmetallic material with a rigid metallic reinforcement.

3.11 Nonmetallic MPT – A tubing constructed completely of nonmetallic materials.

3.12 Working Temperature – The temperature to which the MPT is subjected during its intended use.

#### 4 General Requirements

4.1 MPT covered by this Standard is intended for use as a system with particular fittings or clamps in compliance with [5.5](#).

When intended for use with clamps, MPT may be evaluated without identified particular fittings.

4.2 MPT and associated fittings are permitted to be designated for use in wet locations or in dry locations only.

4.3 MPT and associated fittings intended for use in wet locations, including outdoors, are considered liquid-tight and shall comply with all applicable requirements including the tests in [6.8](#) and [6.12](#). See Marking in [7.1](#) and [7.2](#).

4.4 MPT and associated fittings intended only for use in dry locations need not be subjected to the tests in [6.8](#) and [6.12](#). See Marking in [7.1](#) and [7.2](#).

4.5 Tubing, fittings or clamps with metallic components that will be exposed after installation and become energized in case of a conductor fault shall comply with the electrical resistance test in [6.13](#).

4.6 Working temperature of the MPT is 50° C (122° F) maximum and minus 18° C (0° F) minimum. Temperature ratings greater than 50°C (122°F) can be obtained according to the test in [6.11](#).

4.7 Where specific assembly techniques are required for fittings, instructions for proper assembly shall be provided with the fitting when shipped from the factory.

4.8 For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0.

## **5 Construction**

### **5.1 Nonmetallic MPT**

5.1.1 Nonmetallic MPT shall be:

- a) A layered construction that consists of a jacket or lining, or both, that is integral to the nonmetallic flexible material, with or without a rigid nonmetallic reinforcement (core) embedded in the wall;
- b) A construction with internal and external surfaces, formed of a homogeneous nylon (polyamide) compound; or
- c) Another construction that meets the performance requirements of this Standard.

### **5.2 Composite MPT**

5.2.1 Composite MPT shall be:

- a) A layered construction that consists of a jacket or lining, or both, with a metallic reinforcement; or
- b) Another construction that meets the performance requirements of this Standard.

### **5.3 Dimensions**

5.3.1 The manufacturer shall provide the critical dimensions for MPT.

### **5.4 Internal surface**

5.4.1 The internal surface of MPT and fittings shall be free from obstructions that can cause abrasion or hinder free passage of the conductors, wires and cables.

### **5.5 Fittings and clamps**

5.5.1 A metallic fitting, nonmetallic fitting, or composite fitting for MPT shall be provided with a smooth end stop.

## **6 Tests**

### **6.1 Test specimens**

6.1.1 MPT – fittings and clamps, or combinations thereof, shall be subjected to the appropriate tests as detailed in [Table 1](#).

6.1.2 Unless otherwise specified, a fitting or clamp shall be assembled as intended and in accordance with the manufacturer's instruction prior to each test.

## 6.2 Pre-conditioning and test conditions

6.2.1 Unless otherwise specified all testing, except flammability, should be conducted at  $23 \pm 5^{\circ}\text{C}$  ( $73 \pm 9^{\circ}\text{F}$ ) and a relative humidity of  $50 \pm 10\%$ . Flammability testing shall be conducted in still air at a temperature of  $15 - 35^{\circ}\text{C}$  ( $59 - 95^{\circ}\text{F}$ ) and a relative humidity of  $< 75\%$ . All samples shall be pre-conditioned at  $23 \pm 5^{\circ}\text{C}$  ( $73 \pm 9^{\circ}\text{F}$ ) and a relative humidity of  $50 \pm 10\%$  for a minimum of 30 minutes prior to test.

## 6.3 Identification of materials

6.3.1 Appropriate specimens of each nonmetallic material employed in the construction of nonmetallic MPT, composite MPT and nonmetallic and composite fittings or clamps shall be subjected to the Infrared Spectroscopy (IR) test, as specified in UL 746A or CAN/CSA C22.2-No. 0.17.

In Mexico, this requirement does not apply.

## 6.4 Vertical flame

6.4.1 Three samples each of the smallest, intermediate, and largest size of nonmetallic MPT, composite MPT, or clamps and fittings in a range shall be separately subjected to two 15 s applications of flame, the period between applications being 15 s. If a range of colors is available, samples in accordance with [6.4.2](#) shall be tested. The tubing shall be tested in accordance with [6.4.7](#) to [6.4.14](#). A fitting or clamp shall be tested in accordance with [6.4.7](#) to [6.4.9](#) and [6.4.12](#) to [6.4.14](#). See [Figure 1](#) for essential dimensions for positioning tubing for the vertical flame test. See [Figure 2](#) for essential dimensions for positioning a fitting or clamp for the vertical flame test.

6.4.2 Specimens of the lightest and darkest colors in the color range shall be provided. When a color in the range contains certain pigments which are known to affect flammability characteristics, specimens of that color shall also be provided. If a range of colors are not desired or available testing of a specific color is only considered representative of that color.

6.4.3 The MPT shall not be acceptable if it:

- a) Continues to flame longer than 60 s after the second application of the flame;
- b) Shows more than 25% of the indicator flag burned away or charred after the first or second application of the flame. Soot that can be removed with a cloth or the fingers and brown scorching shall be ignored; or
- c) Emits flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure. Flameless charring of the cotton shall be ignored.

6.4.4 The fitting or clamp shall not be acceptable if it:

- a) Continues to flame longer than 60 s after the second application of the flame; or
- b) Is completely consumed.

6.4.5 The nonmetallic or composite MPT need not be subjected to this test if:

- a) It is made of a material that is designated V-0 or V-1 (small-scale flame test rating), in accordance with UL 94 or CAN/CSA-C22.2 No. 0.17; and
- b) Its minimum thickness is at least the same thickness as the material qualified as V-0 or V-1.

6.4.6 A nonmetallic or composite fitting or clamp need not be subjected to the test if:

a) It is made of a material that is designated V-0, V-1 or V-2 (small-scale flame test ratings), in accordance with UL 94 or CAN/CSA-C22.2 No. 0.17 or NMX-J-565/3-ANCE; and

b) Its minimum thickness is at least the same thickness as the material qualified as V-0, V-1 or V-2.

6.4.7 This test shall be performed on specimens after conditioning, in accordance with [6.2](#), in a 3-sided metal enclosure in an exhaust hood or cabinet. The metal enclosure shall be 305 mm (12 in) wide, 355 mm (14 in) deep, 610 mm (25 in) high, and the top and front shall be open. A 457 mm (18 in) specimen cut from a length of finished MPT shall be secured at both ends with its longitudinal axis vertical in the center of the enclosure. A fitting or clamp shall be secured with its longitudinal axis vertical in the center of the enclosure.

6.4.8 A burner conforming to ASTM D 5025 or NMX-J-565/3-ANCE that has a bore of 9.5 mm (3/8 in) and a length of 100 mm (4 in) from the top of the air-inlet openings to the top of the mixing tube, or an equivalent burner capable of providing the flame in accordance with ASTM D 5207 or NMX-J-565/3-ANCE, shall supply the flame. While the barrel is vertical and the burner is well away from the specimen, the overall height of the flame shall be adjusted to approximately 100 to 125 mm (4 to 5 in). The blue inner cone shall be 38 mm (1-1/2 in) high, and the temperature at its tip shall be 816°C (1500°F) or higher as measured using a chromel-alumel (nickel-chromium and nickel-manganese aluminum) thermocouple or an equivalent calibrated instrument. Without disturbing the adjustments for the height of the flame, the valve supplying gas to the burner flame and the separate valve supplying gas to any pilot flame shall be closed.

6.4.9 A wedge (dimensions are specified in [Figure 3](#)) to which the base of the burner can be secured shall be provided for tilting the barrel 20 degrees from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The burner shall be secured to the wedge and the assembly shall be placed in an adjustable support jig. The jig shall be adjusted toward one side or the other of the enclosure to place the longitudinal axis of the barrel in the vertical plane that contains the longitudinal axis of the specimen. The plane shall be parallel to the sides of the enclosure. The jig shall also be adjusted toward the rear or front of the enclosure to position point A, which is the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel, 38 mm (1-1/2 in) from point B 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 touches the center of the front of the specimen. In the absence of a gas pilot light on the burner, the support for the burner and wedge shall be arranged so as to enable the burner to be quickly removed from and precisely returned to the same position where it remains for the duration of each flame application.

6.4.10 When testing a specimen of nonmetallic and composite MPT, a flat, horizontal layer of untreated surgical cotton 6 to 25 mm (1/4 to 1 in) thick shall cover the floor of the chamber. The upper surface of the floor of the chamber shall be 229 to 241 mm (9 to 9-1/2 in) below point B, which is the point at which the tip of the blue inner cone of the test flame touches the specimen (see [Figure 1](#)). An additional layer of cotton shall be placed on the wedge and around the base of the burner. These layers of cotton shall be arranged so as not to be disturbed during the performance of this test. No cotton is required when testing fittings or clamps.

6.4.11 For nonmetallic and composite MPT, a strip of unreinforced 94 g/m<sup>2</sup> (60 lb) kraft paper that is 13 mm (1/2 in) wide, approximately 0.1 mm (5 mil) thick, and is gummed on one side shall be used to make an indicator flag. The gumming shall be moistened just to facilitate adhesion. With the gum toward the specimen, the strip shall be wrapped around the specimen once with its lower edge 254 mm (10 in) above point B, the point at which the blue inner cone touches the specimen. The ends of the strip shall be pasted together evenly and trimmed to provide a flag that projects 19 mm (3/4 in) from the tubing toward the rear of the enclosure, with the flag parallel to the sides of the enclosure (see [Figure 1](#)). The lower clamp or other support for the tubing shall be adjusted vertically to keep it from being any closer than 76 mm (3 in) to point B.



6.4.12 If the burner has a gas pilot light, the valve supplying gas to the pilot shall be opened and the pilot lit. If the burner does not have a gas pilot light, the burner shall be supported as indicated in [6.4.9](#) in a position away from the specimen and then lit. This operation and the remainder of the test shall be conducted under a forced-draft exhaust hood or cabinet operating to remove smoke and fumes, but not having drafts that affect the flame.

6.4.13 If the burner has a gas pilot light, the valve supplying gas to the burner shall be opened to apply the flame to the specimen automatically. This valve shall be held open for 15 s, closed for 15 s, and so forth for a total of two 15-s applications of the gas flame to the specimen with 15 s between applications. If the burner does not have a gas pilot light, the burner shall be moved into position to apply the gas flame to the specimen, kept there for 15 s, removed for 15 s, and so forth for a total of two 15 s applications of the gas flame to the specimen with 15 s between applications. The gas flame shall be reapplied to the specimen 15 s after the first application regardless of whether flaming of the specimen ceases of its own accord within 15 s of the first application.

6.4.14 The gas supply shall be either technical grade methane gas (min. 98% pure) or natural gas, both having a heat content of approximately  $37 \pm 1 \text{ MJ/m}^3$  ( $993 \pm 27 \text{ Btu/ft}^3$ ), and shall be delivered with a regulator and meter for uniform gas flow.

## 6.5 Tension

6.5.1 Three samples of MPT shall withstand a tension of 156 N (35 lbf) for one min applied in accordance with [6.5.2](#) or [6.5.3](#). Each sample shall be approximately 610 mm (2 ft) in length. Following the test, the MPT shall be free of cracks or the separation of convolutions when it is examined under normal or corrected-to-normal vision. For the purpose of this test, the range of sizes of tubing constructed of the same material is permitted to be represented by the smallest size and by a specimen having the thinnest wall. For the purpose of this test, any one color is permitted to represent the range of colors.

6.5.2 For a test using a weight and either a block and tackle or a differential pulley, each 1.1-m (44-in) specimen of the tubing shall be fastened in the clamps so that its ends project about 50 mm (2 in) beyond the edges of each clamp. The result is a specimen that is 0.9 m (36 in) long between the clamps, which are then to be tightened to keep the specimen from slipping.

6.5.3 For a test using a testing machine, a 457 mm (18 in) specimen shall be gripped in the jaws of the machine. To prevent the jaws from crushing the specimen, round metal plugs shall be inserted into the ends of the specimen. The jaws shall then be separated at a rate of  $50 \pm 5 \text{ mm/min}$  ( $1.0 \pm 0.2 \text{ in/min}$ ) until the specimen is under tension by the force specified in [6.5.1](#). This level of tension shall be maintained for 60 s and shall then be released at the same rate at which it was applied. For any adjustment necessary for maintaining the tension during the 60 s, the jaws shall be separated at the rate of  $12.5 \pm 3.0 \text{ mm/min}$  ( $1/2 \pm 1/8 \text{ in/min}$ ).

## 6.6 Flexibility

6.6.1 After being exposed to a temperature of minus  $18 \pm 1^\circ\text{C}$  ( $0 \pm 2^\circ\text{F}$ ) for a period of not less than 4 h, three samples each of the nonmetallic MPT or composite MPT shall be bent around a mandrel having a diameter as specified in [Table 2](#). The tubing shall be free of cracks and the separation of convolutions when it is examined under normal or corrected-to-normal vision. For the purpose of this test, range of sizes of tubing constructed of the same material is permitted to be represented by an intermediate size and by a specimen having the thinnest wall. For the purpose of this test, any one color is permitted to represent the range of colors.

6.6.2 Compliance with the flexibility test in [6.6.1](#) shall be determined by wrapping a sufficient length of specimen around the test mandrel. The specimen shall be bent  $360^\circ$  around the mandrel, straightened,

then bent 360° around the mandrel in the opposite direction and straightened again. The test shall be conducted within 15 s after removal from the cold chamber.

## 6.7 Cold impact

6.7.1 Ten specimens of nonmetallic MPT or composite MPT at least 150 mm (6 in) in length shall be exposed to a temperature of minus  $18 \pm 1^{\circ}\text{C}$  ( $0 \pm 2^{\circ}\text{F}$ ) for a period of not less than 4 h. The specimens shall then be subjected to an impact of 12.2 J (9 ft-lbf). The MPT shall not have cracks or separation of convolutions in more than two out of ten specimens when examined under normal or corrected-to-normal vision. For the purpose of this test, the range of sizes of tubing constructed of the same material is permitted to be represented by an intermediate size and by a specimen having the thinnest wall. For the purpose of this test, any one color is permitted to represent the range of colors.

6.7.2 The impact test in [6.7.1](#) shall be performed using Tup B having a 9 kg (20 lb) mass in accordance with ASTM D 2444. The test shall be conducted inside the cold chamber or within 15 s after removal from the cold chamber.

## 6.8 Weather resistance

6.8.1 Nonmetallic MPT or composite MPT intended for outdoor installation shall have a sufficient length exposed for 1000 h to the Xenon lamp in a weatherometer chamber, in accordance with the procedure outlined in ASTM G 155, each cycle consisting of 102 min of light and 18 min of light and water spray. The specimen shall be hung vertically in the drum of the apparatus. After this conditioning, the specimen shall be subjected to a temperature of minus  $18 \pm 1^{\circ}\text{C}$  ( $0 \pm 2^{\circ}\text{F}$ ) for 1 h. While still at this temperature, or within 15 s of removal from the cold chamber, the MPT shall be wrapped one complete turn around the mandrel having a diameter as specified in [Table 2](#).

Note: Due to equipment limitations, sample specimens should not be larger in diameter than 34.6 mm (1.364 in).

6.8.2 For the purpose of this test, a range of sizes of tubing constructed of the same material is permitted to be represented by an intermediate size in the range and by a specimen having the thinnest wall. Specimens in the lightest and darkest colors shall be provided and considered representative of the color range.

Note: If a range of colors are not desired or available, testing of a specific color is only considered representative of that color.

6.8.3 After the conditioning and bending, the surface of the nonmetallic MPT or composite MPT shall not show any cracks or separation of convolutions when examined under normal or corrected-to-normal vision.

## 6.9 Flame test in cable trays – FT4 (optional)

6.9.1 Nonmetallic MPT or composite MPT, which is intended to be marked FT4 according to [7.1.1](#), shall comply with the Vertical Flame Test (FT4) Conduit or Tubing in Cable Tray in accordance with CSA C22.2 No 211.0.

Note: The FT4 flame test is a National Building Code of Canada requirement in designated applications in noncombustible construction buildings.

## 6.10 Pull-out

6.10.1 Three samples each of the smallest, intermediate and largest sizes of fittings in a range having the same material and construction type shall be assembled in the intended manner to approximately a 500 mm (20 in) length of the MPT. The MPT shall not pull out of the fitting when subjected to the

appropriate force in (a) or (b) for 1 min applied in accordance with the method described in [6.5.2](#) or [6.5.3](#). The fittings shall be assembled either by threading to a box having a compatibly threaded hub or to a box or metal plate with appropriate size knockout when a locknut is provided with the fitting. For threading, the fittings shall be assembled handtight unless the manufacturer instructs otherwise. Locknuts shall be assembled handtight plus one-quarter turn

- a) 80 N (18 lbf) for tubing having an inside diameter less than 17 mm (11/16 in);
- b) 156 N (35 lbf) for tubing having an inside diameter of 17 mm or larger.

6.10.2 Each distinct type of tubing constructed of the same material(s) for which the fittings are intended to be used shall be tested.

6.10.3 Any one color in the range of fittings of the same material and construction type is permitted to represent others in the range for the purpose of this test.

6.10.4 Where fittings in a range include both straight and angled designs provided with the same means of securement to the MPT and to the enclosure, only the straight fitting design shall be tested. The results shall be considered representative of the entire range.

## 6.11 Heat aging

6.11.1 Two specimens of the largest size in a range of nonmetallic MPT or composite MPT tubing approximately 610 mm (24 in) in length shall be placed in a full-draft, circulating-air oven at a temperature indicated in [Table 3](#) or 168 h. The tubing shall then be removed from the oven and allowed to cool to room temperature for no more than 4 h. After cooling, there shall be no cracks or other visible signs of deterioration on the tubing as a result of the exposure.

6.11.2 A polymeric material that has been previously investigated and determined to have a relative thermal index (RTI-Strength) at or above the manufacturers declared working temperature in accordance with [4.6](#) at the minimum thickness of the nonmetallic MPT or polymeric layer of composite MPT, need not be subjected to the requirement in [6.11.1](#). RTI shall be determined by UL 746B or CSA C22.2 No. 0.17.

In Mexico, this requirement does not apply.

6.11.3 The apparatus for the air oven aging of specimens shall be as indicated for a Type II oven in ASTM D 5423 or NMX-J-417-ANCE, and shall circulate the air within the aging chamber at high velocity. A portion of the air may be recirculated, but a substantial amount of fresh air shall be admitted continuously to maintain an essentially normal oxygen content in the air surrounding the specimens. The exhaust ports of the oven shall be adjusted to achieve 100 to 200 complete fresh-air changes per hour. The blower or other means for circulating the air shall be located entirely outside the aging chamber. The oven shall maintain the specified temperature within 2.0°C (3.6°F).

## 6.12 Liquid tightness

6.12.1 Three samples each of the smallest, intermediate and largest sizes of fittings in a range, having the same material and construction type and intended for use in wet locations, shall be assembled in the intended manner to an approximate 500-mm (20-in) length of MPT, intended for use with the fitting, of the same type and to an appropriate enclosure. When subjected for 30 min. to the oil spray test described in [6.12.6](#), there shall be no entrance of oil at either the interface of the tubing or enclosure. This test is not required for fittings intended for use only in dry locations and marked in accordance with [7.2](#).

6.12.2 A fitting intended for mounting either in a threaded opening or a knockout of an enclosure shall be tested in the appropriate size knockout. The results of the test represent installation in a threaded opening.

A fitting only intended for mounting in a threaded opening or only in a knockout shall be tested when mounted as instructed by the manufacturer and shall be marked according to [7.2.2](#). Unless otherwise specified in the manufacturer's instructions, a locknut provided with a fitting shall be assembled hand-tight plus one-quarter turn.

6.12.3 Each distinct type of tubing constructed of the same material for which the fittings are intended to be used shall be tested.

6.12.4 Any one color in the range of MPT and fittings of the same material and construction type is permitted to represent others in the range for the purpose of this test.

6.12.5 Where fittings in a range include both straight and angled designs provided with the same means of securement to the MPT and to the enclosure, only the straight fitting design shall be tested. The results shall be considered representative of the entire range.

6.12.6 The assembled fitting, enclosure and MPT shall be set up at an angle of 45° from the vertical so that a stationary nozzle with a 9.5-mm (3/8-in) diameter opening is located 250 mm (10 in) above the MPT and directed to spray oil vertically downward so as to strike the MPT approximately 25 mm (1 in) above the fitting. The mixture shall consist of one part of water-soluble oil with a viscosity of 0.3 and ten parts of water, and the mixture shall be sprayed through the nozzle at a rate of 7.6 l/min (2 gal/min).

### 6.13 Electrical resistance test

6.13.1 Three samples each of the smallest, intermediate and largest size fitting and MPT shall be assembled as intended in accordance with the manufacturer's instructions if provided. Each distinct type of tubing constructed of the same metallic material for which the fittings are intended to be used shall be tested.

6.13.2 The resistance between the points specified in [6.13.3](#) shall not cause a voltage drop greater than 50 mV. The resistance shall be determined by passing a direct current of 30 amperes through the fitting and connections between the fitting, the MPT and the metal enclosure to which the fitting is assembled, and through a 305-mm (12-inch) length of MPT. For a connector intended for assembly in a knockout, a metal plate used to simulate an enclosure shall be allowed to be used for the test.

6.13.3 For a coupling, the voltage drop shall be measured between two points, one on each section of the MPT. For a connector, the voltage drop shall be measured between a point on the MPT and a point on the metal enclosure. For the MPT, the voltage drop shall be measured between points at either end of a 305-mm (12-inch) length of MPT. The point on the metal enclosure shall be 1.6 mm (1/16 in) from the fitting. The point on the MPT shall be 1.6 mm (1/16 in) from the fitting or the contact point between the fitting and the MPT. For a connector intended for assembly in a knockout, a metal plate used to simulate an enclosure shall be allowed to be used for the test.

6.13.4 Where fittings in a range include both straight and angled designs provided with the same means of securement to the MPT and to the enclosure, only the straight fitting design shall be tested. The results shall be considered representative of the entire range.

### 6.14 Protective coating for ferrous metal MPT fittings, clamps and components

6.14.1 Three samples of a fitting, clamp, or component with a protective coating shall comply with the requirements for coatings on metallic surfaces in accordance with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B/CSA C22.2 No. 18.3/NMX-J-017-ANCE, 5.1.3.