Association of Standardization and Certification
NMX-J-536-ANCE
Third Edition

CSA Group
CSA C22.2 No. 83.1-07
Second Edition

Underwriters Laboratories Inc.
UL 797
Ninth Edition

Electrical Metallic Tubing – Steel

November 30, 2007

(Title Page Reprinted: April 28, 2023)

Approved American National Standard

ANSI/UL 797-2023

Standard for Safety for Electrical Metallic Tubing – Steel

Second Edition, Dated November 30, 2007

Summary of Topics

This revision dated April 28, 2023 includes the following changes in requirements:

– Introduction of a Range for the Specific Gravity; 6.2.2.1

– Electrical Metallic Tubing, Addition of trade sizes 5" & 6" in Steel; 5.1.2, Table 5.1, 6.2.2.5, Table 5.2, B.1 and Table F1

– Removal of "for reference only (not a requirement)" from Table 5.2

Commitment for Amendments

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

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This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through April 28, 2023. The most recent designation of ANSI/UL 797 as an American National Standard (ANSI) occurred on April 28, 2023. 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 797 on January 25, 1982. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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Preface

This is the harmonized ANCE, CSA Group, and UL standard for electrical metallic tubing – steel. It is the third edition of NMX-J-536-ANCE, the second edition of CSA C22.2 No. 83.1, and the ninth edition of UL 797. This edition of CSA C22.2 No. 83.1 supersedes the previous edition published in 2004. This edition of UL 797 supersedes the previous edition published June 30, 2004. This harmonized standard has been jointly revised on April 28, 2023. For this purpose, CSA Group and UL are issuing revision pages dated April 28, 2023, and ANCE is issuing a new edition dated April 28, 2023.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc. (UL), and the conduit manufacturing industry. The efforts and support of the Technical Harmonization Subcommittee for Conduit and Tubing, of the Council of 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 Accesories from the Comite de Normalizacion de la Asociacion de Normalizacion y Certificacion, A.C., CONANCE, with the collaboration of the Electrical Metallic tubing – steel manufacturers and users.

This standard was reviewed by the CSA Subcommittee on Metal Conduit and Tubing, 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 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 an IEC format, but is not based on, nor is it to be considered equivalent to an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical deviations are allowed for codes and governmental regulations and 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 to be word for word except for editorial changes.

Reasons for differences from IEC

The Technical Harmonization Subcommittee identified several IEC standards that address electrical conduit and tubing included in the scope of this standard. The IEC standards for electrical conduit and tubing are recognized as being generally system-specific, containing the requirements for the relevant conduits, tubing, and associated fittings in several discrete IEC standards.

3.6 Electrical metallic tubing – steel (EMT). An unthreaded steel raceway of circular cross-section designed for the physical protection and routing of wire conductors and for use as an equipment grounding conductor when installed utilizing appropriate fittings.

3.7 Primary coating. A coating on the outside of the tubing for protection against corrosion. See Clause 5.3.1.1.

3.8 Supplementary coating. A coating on the outside of the tubing in addition to the primary coating, for protection against severe corrosive conditions. See Clause 5.3.5.

4 Units of measurement

4.1 In Canada and Mexico, the values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

In the United States, the values stated in either SI units or inch-pound units shall be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems can result in nonconformance with the standard.

5 Construction

5.1 Tube

5.1.1 Each tube shall be of steel, shall be straight, and shall have a circular cross-section. All seams shall be thoroughly welded.

5.1.2 A welded seam shall not have metal trimmings, sharp edges, or sharp projections on the interior or exterior surfaces of the tube. A slight bead on the interior wall at the weld line shall be allowed if the bead is not sharp and if the bead does not exceed 0.38 mm (0.015 in) in height for the trade size 16 – 53 (1/2 – 2) or 0.51 mm (0.020 in) in height for the trade size 63 – 155 (2-1/2 – 6).

5.1.3 Before the protective coating is applied, the interior and exterior surfaces of each tube shall be free from scale, flash, or any other protrusion, other than as specified in Clause 5.1.2.

5.1.4 The end of the tubing shall be cut off squarely and shall be without any burrs and sharp edges.

5.1.5 Electrical metallic tubing shall not be threaded unless the integral fittings mentioned in Clause 5.5 are steel, and the thread is not of the standard pipe-thread dimensions.

5.2 Finished tubing

5.2.1 The outside diameter and the minimum weight of finished electrical metallic tubing shall be as indicated in Table 5.1. The standard length of electrical metallic tubing shall be 3.05 m (10 ft) ±6 mm (±1/4 in). Each length of EMT shall be examined visually on both exterior and interior surfaces to determine the absence or presence of poor coatings, hard scale, burrs or fins, or other defects. See Annex D.

5.2.2 Lengths, other than standard lengths, shall have a minimum acceptable weight proportional to the weights specified in Table 5.1. The length tolerances in Clause 5.2.1 shall be applicable for non-standard lengths.

Table 5.1
Dimensions and Weights

Metric designator	Outside diameter, mm	Minimum acceptable weight, kg/m	Trade size	Outside diameter, in	Minimum acceptable weight, lbs/ft
16	17.93 ± 0.13	0.424	1/2	0.706 ± 0.005	0.285
21	23.42 ± 0.13	0.647	3/4	0.922 ± 0.005	0.435
27	29.54 ± 0.13	0.952	1	1.163 ± 0.005	0.640
35	38.35 ± 0.13	1.414	1-1/4	1.510 ± 0.005	0.950
41	44.20 ± 0.13	1.637	1-1/2	1.740 ± 0.005	1.10
53	55.80 ± 0.13	2.083	2	2.197 ± 0.005	1.40
63	73.03 ± 0.25	3.051	2-1/2	2.875 ± 0.010	2.05
78	88.90 ± 0.38	3.720	3	3.500 ± 0.015	2.50
91	101.60 ± 0.50	4.837	3-1/2	4.000 ± 0.020	3.25
103	114.30 ± 0.50	5.506	4	4.500 ± 0.020	3.70
129	141.30 ± 0.50	2.732	5	5.563 ± 0.020	7.00
155	168.28 ± 0.50	3.263	6	6.625 ± 0.020	8.37

5.2.3 Other dimensions of EMT complying with the requirements in this standard are provided in Annex B for information only.

5.3 Protective coatings

5.3.1 General

5.3.1.1 The exterior surface of EMT shall be protected against corrosion by a coating solely of zinc, as described in Clause 5.3.2, or an alternate corrosion-resistant coating, as described in Clause 5.3.3. The interior surface of the tubing shall be protected against corrosion by a coating of zinc or an organic coating, as described in Clauses 5.3.2 and 5.3.4 respectively. See Annex C for an overview.

5.3.2 Zinc coating

5.3.2.1 A protective coating of zinc shall cover completely, shall adhere firmly at all points, shall be smooth and free from blisters and other defects that can lessen the protective value of the coating, shall be in metal-to-metal contact with the steel, and shall comply with Clause 6.2.2.

5.3.3 Alternate corrosion-resistant coating

5.3.3.1 An alternate corrosion-resistant coating shall cover completely, shall adhere firmly at all points, and shall be smooth and free from blisters and other defects that can lessen the protective value of the coating.

5.3.3.2 An alternate corrosion-resistant coating shall comply with the requirements of Clause 6.2.4. The tubing or elbow shall be subjected to the assembly, bending, resistance, pull, and fault current tests in accordance with Reference Item No. 3, Annex A, with both set-screw and compression type couplings, without removal of the alternate corrosion-resistant coating.

5.3.3.3 Tubing provided with a nonmetallic alternate corrosion-resistant coating that is not marked with a temperature designation, or is marked "90°C" (“200°F”), is for use in ambient temperatures that do not exceed 90°C (200°F). It is not prohibited that tubing provided with a nonmetallic alternate corrosion-resistant coating that is for use at temperatures in excess of 90°C (200°F) be marked with a rating that has been evaluated in accordance with Clause 6.2.4.4.1.

Table 5.2
Minimum Dimensions of Elbows

Metric Designator	Radius R to Centerline of Tubing, mm	Length L_s of Each Straight End Portion of Tubing, mm	Trade Size	Radius R to Centerline of Tubing in	Length L_s of Each Straight End Portion of Tubing, in
16	102	38	1/2	4	1-1/2
21	114	38	3/4	4-1/2	1-1/2
27	146	48	1	5-3/4	1-7/8
35	184	51	1-1/4	7-1/4	2
41	210	51	1-1/2	8-1/4	2
53	241	51	2	9-1/2	2
63	267	76	2-1/2	10-1/2	3
78	330	79	3	13	3-1/8
91	381	83	3-1/2	15	3-1/4
103	406	86	4	16	3-3/8
129	610	92	5	24	3-5/8
155	762	95	6	30	3-3/4

5.5 Expanded-end integral couplings

5.5.1 Electrical metallic tubing may be provided with an integral fitting such as an expanded end. Each such fitting shall comply with the relevant standard for fittings for conduit, tubing, and cable in Reference Item No. 6, Annex A.

6 Test requirements

6.1 Tube

6.1.1 At ambient temperature, one specimen of the smallest available trade size of EMT shall be capable of being bent into a quarter of a circle, without the formation of any cracks in the metal, the opening of seam or weld, or the appreciable distortion of the circular cross-section of the tube. Compliance of tubing with this requirement regarding cracks and openings shall be determined, after bending, by subjecting the tubing to a visual examination.

6.1.2 After being conditioned at a temperature of 0°C (32°F) for 60 min, one specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle using any suitable bending equipment capable of producing elbows with a radious of the curve to the centerline not less than that referenced in Table 5.2. The same specimen may also be used to determine compliance with the coating test in Clause 6.2.1.3. Compliance shall be determined by bending the tube using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2. The tube shall not develop a crack and the weld shall not open. The test shall be conducted inside the cold chamber or shall begin within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below "0°C" ("32°F") shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.1.3 *Deleted*

6.2 Protective coatings

6.2.1 General

6.2.1.1 The protective coating used on the interior or exterior of the tubing shall not crack or flake, as visible using normal or corrected to normal vision, when a finished specimen of the smallest available trade size produced by the manufacturer is tested at ambient temperature. Testing shall be performed by bending the tubing into a semi-circle, using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2.

6.2.1.2 *Deleted*

6.2.1.3 One specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2 being conditioned at a temperature of 0°C (32°F) for 60 min. The tube shall not develop a crack and a weld shall not open. The coatings shall not be damaged to the extent that bare metal is exposed or that the coating separates from the metal. The test shall be conducted inside the cold chamber or begun within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below "0°C" ("32°F") shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.2.1.4 For identification of compounds, a nonmetallic material used as an alternate corrosion-resistant or organic coating shall be subjected to the infrared spectroscopy (IR), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC) tests specified in the applicable standard for polymeric materials. See Reference Item No. 7, Annex A.

6.2.1.5 The supplementary coating described in Clause 5.3.5 need not comply with 6.2.1.1.

6.2.2 Zinc coating

6.2.2.1 A solution of copper sulfate for this test shall be made from distilled water and a reagent grade of cupric sulfate ($CuSO_4$). In a copper container or in a glass, polyethylene, or other chemically nonreactive container in which a bright piece of copper is present, a quantity of the cupric sulfate shall be dissolved in hot distilled water. The purpose is to obtain a solution that has a specific gravity within the range of 1.183 to 1.189 after the solution is cooled to a temperature of 18.3°C (65.0°F). As necessary, any free acid that might be present shall be neutralized by the addition of approximately 1 gram of cupric oxide (CuO) or 1 gram of cupric hydroxide ($Cu(OH)_2$) per liter of solution. The solution shall then be diluted with distilled water to obtain a specific gravity within a range of 1.183 to 1.189 at a temperature of 18.3°C (65.0°F). The solution shall then be filtered.

6.2.2.2 Several 150-mm (6-in) specimens shall be cut from a sample length of the finished zinc-coated tubing. With prudent attention to the risks to health and to the risk of fire, the specimens shall be cleaned with a suitable organic solvent. Each specimen shall be examined for evidence of damage to the zinc coating, and only specimens that are not damaged shall be selected for use in the test. When a zinc coating is used on the inside and outside of the tubing, half of the specimens shall be longitudinally cut in half to expose the inside surface. If a zinc coating is used only on the outside of the tubing, none of the specimens shall be cut longitudinally.

6.2.2.3 The selected specimens shall be rinsed in water, and all surfaces shall be dried with clean cheesecloth. As much of the water as possible shall be removed in the drying operation because water slows the reaction between the zinc and the solution, thereby adversely affecting the test results. The surface of the zinc shall be dry and clean before a specimen is immersed in the solution of copper sulfate.

The specimens shall not be touched by the hands or anything else that can contaminate or damage the surfaces.

6.2.2.4 A glass, polyethylene, or other chemically nonreactive beaker having a diameter equal to approximately twice the diameter measured over the specimen shall be filled with the solution of copper sulfate to a depth of not less than 76 mm (3 in). The temperature of the solution shall be maintained at 18.3 ±1.1°C (65.0 ±2.0°F). The specimen shall be immersed in the solution and supported on end in the center of the beaker so that not less than 64 mm (2-1/2 in) of its length is immersed. The specimen shall remain in the solution for 60 s, during which time it shall not be moved, nor shall the solution be stirred.

6.2.2.5 At the end of the 60 s period, the specimen shall be removed from the beaker, rinsed immediately in running tap water, rubbed with clean cheesecloth until any loosely adhering deposits of copper are removed, and then dried with clean cheesecloth. Again, hands and other damaging and contaminating objects and substances shall not touch the surfaces that were immersed. The part of the specimen that was immersed shall be examined, considering each broad surface separately and disregarding the portions of the specimen within 13 mm (1/2 in) of the cut ends on sizes 12 – 53 (3/8 – 2) and 25 mm (1 in) for sizes 63 – 155 (2-1/2 – 6) and within 3 mm (1/8 in) of any longitudinal edges cut in the process of preparing the specimen.

6.2.2.6 A record shall be made when the immersed part of the specimen has any deposit of bright, firmly-adhering copper exclusive of the 13 mm (1/2 in) cut-end portions and any 3 mm (1/8 in) longitudinal cut-edge portions.

6.2.2.7 When bright adhering copper is not found, the process of immersing, washing, rubbing, drying, examining, and recording shall be repeated up to the required number of immersions, or until the presence of copper is noted, whichever comes first, using the same specimen and beaker of solution. After the dips are completed on any one specimen, the portion of the solution of copper sulfate used shall be discarded. A fresh portion of the solution shall be employed for each of any succeeding specimens.

6.2.2.8 A protective zinc coating that provides the sole means of primary corrosion resistance on the exterior of the tubing shall be such that a specimen of the finished tubing does not show a bright, adherent deposit of copper after four 60-s immersions in a copper sulfate solution.

6.2.2.9 A protective zinc coating that provides the sole means of primary corrosion resistance on the interior of the tubing shall be such that a specimen of the finished tubing does not show a bright, adherent deposit of copper after one 60-s immersion in a copper sulfate solution.

6.2.2.10 When it is desired to show the character of the bright metallic copper deposit on an exposed steel surface, prepare a reference standard for comparison as follows. Partially submerge a zinc-coated specimen in strong hydrochloric acid until a violent action ceases. Immediately remove the specimen, wash, and wipe it dry. Then dip the specimen, with an area of bare surface thus exposed, including a portion with zinc coating intact, for a few seconds in the copper sulfate solution at a temperature of 16 – 20°C (61 – 66°F), remove it, wash it, and wipe it dry. Prepare this copper-coated reference standard at the time of testing.

6.2.2.11 For an alternate test method to the one described in Clauses 6.2.2.1 – 6.2.2.10, see Reference Item No. 8, Annex A.

Annex B (informative)

B.1 Dimensions of EMT – Steel

(See Clause 5.2.3)

(For information only)

Metric designators	Internal diameter, mm	Wall thickness, US and Canada, mm	Wall thickness, Mexico, mm	Trade size	Internal diameter, in	Wall thickness, US and Canada, in	Wall thickness, Mexico, in
16	15.80	1.07	1.1	1/2	0.622	0.042	0.042
21	20.93	1.24	1.2	3/4	0.824	0.049	0.049
27	26.64	1.45	1.5	1	1.049	0.057	0.060
35	35.05	1.65	1.5	1-1/4	1.380	0.065	0.060
41	40.89	1.65	1.5	1-1/2	1.610	0.065	0.060
53	52.50	1.65	1.5	2	2.067	0.065	0.060
63	69.37	1.83	1.8	2-1/2	2.731	0.072	0.072
78	85.24	1.83	1.8	3	3.356	0.072	0.072
91	97.38	2.11	2.1	3-1/2	3.834	0.083	0.083
103	110.08	2.11	2.1	4	4.334	0.083	0.083
129	136.46	2.41	2.4	5	5.373	0.095	0.095
155	163.45	2.41	2.4	6	6.435	0.095	0.095

Annex F (informative)

F.1 Master Bundle Quantity

(See Clauses 7.8 and 7.9)

Table F1
Master bundle quantity – 3.05-m (10-foot) lengths

Trade size	(Metric designator)	Pieces	Feet	(Meters)	Nominal Wt/Lbs	(Wt/kg)
1/2	16	700	7000	2133.6	2100	948.0
3/4	21	500	5000	1524	2300	1037.8
1	27	300	3000	914.4	2010	916.3
1-1/4	35	200	2000	609.6	2020	911.7
1-1/2	41	150	1500	457.2	1740	789.2
2	53	120	1200	365.8	1776	807.4
2-1/2	63	61	610	185.9	1318	598.7
3	78	51	510	155.4	1341	607.8
3-1/2	91	37	370	112.8	1291	585.1
4	103	30	300	91.4	1179	535.2
5	129	25	250	76.2	1390	629.7
6	155	20	200	61.0	1328	601.7

Revision History

CSA C22.2 No. 83.1:07, Electrical Metallic Tubing — Steel — originally published November 2007

Note: *For information about the* ***Standards Update Service*** *or if you are missing any updates go to* ***store.csagroup.org*** *or* ***techsupport@csagroup.org****.*

Revisions issued: Update No. 1 — December 2012

Update No. 2 — March 2021	**Revision symbol (in margin)**
Cover, title page, copyright page, Preface, Clauses 5.4.3, 6.1.2, 6.1.3, 6.2.1.1 – 6.2.1.3, 6.2.1.5, and 6.2.4.11.1, Table 5.2, Figure 2, and Annex A **Note:** *Only the revised pages have been provided.*	1

National Standard of Canada — March 2021
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ICS 29.120.99

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Second Edition, Dated November 30, 2007

Summary of Topics

This revision dated March 30, 2021 includes the following changes in requirements:

– Annex A Normative References Update;

– Interpretation of Flammability Test Result for a Thin Nonmetallic Topcoat (Outermost Layer) of an Alternate Corrosion Protection System; 6.2.4.11.1

– Clarification of Elbow and Bend Radius Requirements, Removal of the Term Mandrel, Addition of Exemption for Supplementary Coatings from Bend Test to Better Align with RMC Standard and Editorial Changes; 5.4.3, Table 5.2, 6.1.2, 6.1.3, 6.2.1.1 – 6.2.1.3, 6.2.1.5 and Figure 2

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Preface

This is the harmonized ANCE, CSA Group, and UL standard for electrical metallic tubing – steel. It is the third edition of NMX-J-536-ANCE, the second edition of CSA C22.2 No. 83.1, and the ninth edition of UL 797. This edition of CSA C22.2 No. 83.1 supersedes the previous edition published in 2004. This edition of UL 797 supersedes the previous edition published June 30, 2004. This harmonized standard has been jointly revised on March 30, 2021. For this purpose, CSA Group and UL are issuing revision pages dated March 30, 2021, and ANCE is issuing a new edition dated March 30, 2021.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc. (UL), and the conduit manufacturing industry. The efforts and support of the Technical Harmonization Subcommittee for Conduit and Tubing, of the Council of 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 Accesories from the Comite de Normalizacion de la Asociacion de Normalizacion y Certificacion, A.C., CONANCE, with the collaboration of the Electrical Metallic tubing – steel manufacturers and users.

This standard was reviewed by the CSA Subcommittee on Metal Conduit and Tubing, 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 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 an IEC format, but is not based on, nor is it to be considered equivalent to an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical deviations are allowed for codes and governmental regulations and 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 to be word for word except for editorial changes.

Reasons for differences from IEC

The Technical Harmonization Subcommittee identified several IEC standards that address electrical conduit and tubing included in the scope of this standard. The IEC standards for electrical conduit and tubing are recognized as being generally system-specific, containing the requirements for the relevant conduits, tubing, and associated fittings in several discrete IEC standards.

The THSC determined the safe use of electrical conduit and tubing is dependent on the design and performance of the conduit and tubing 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 electrical conduit and tubing and associated fittings with those presently addressed in the known IEC standards. The THSC agreed such future investigation might be facilitated by completion of harmonization of the North American standards for electrical conduit and tubing and their fittings.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is to be 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.

5.3.3.4 Tubing provided with a nonmetallic alternate corrosion-resistant coating that is not marked with a temperature designation, or is marked "0°C" (“32°F”), is for use in ambient temperatures not below 0°C (32°F). It is not prohibited that tubing provided with a nonmetallic alternate corrosion-resistant coating that is for use at temperatures below 0° C (32° F) be marked with a rating that has been evaluated in accordance with Clauses 6.2.1.3 and 6.2.4.10.

5.3.4 Organic coating

5.3.4.1 An organic coating shall cover evenly the surface to which it is applied, shall be of uniform quality throughout, shall have a smooth and even appearance, and shall comply with Clause 6.2.3 and the bending requirements of Clause 6.2.1.1.

5.3.5 Supplementary coating

5.3.5.1 The use of one or more supplementary coatings is not prohibited. The supplementary coating or coatings are not required to meet the requirements for primary corrosion-resistant coatings. Tubing or elbows that are provided with supplementary coatings that have not been evaluated for their corrosion resistance characteristics shall be marked in accordance with Clause 7.7.

5.3.5.2 Supplementary nonmetallic coatings shall be evaluated with respect to:

a) flame propagation,

b) detrimental effects on the corrosion resistance provided by the primary protective coatings,

c) the fit of the couplings, and

d) electrical continuity with couplings.

See Reference Item No. 4, Annex A. The supplementary coating shall be provided in addition to the full primary corrosion-resistant coating.

5.3.6 Surface treatment

5.3.6.1 When one or more surface treatments not exceeding 0.0038 mm (0.00015 in) are employed as a top coat or conversion coating, the coatings shall not be required to meet the requirements for an alternate corrosion-resistant coating or organic coating.

5.4 Elbows

5.4.1 Elbows shall be made from the same grade of tubing as that used for straight lengths of EMT and shall be treated, coated, and otherwise produced according to the requirements for EMT. See Annex D.

5.4.2 An elbow may be provided with an integral coupling or other integral fitting on one or both ends. Each fitting shall comply with Reference Item No. 5, Annex A.

5.4.3 The curve of an elbow shall be formed using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2. The curved portion of an elbow shall be smooth and continuous throughout the bend without creases when examined visually under an artifical light source using normal or corrected-to-normal vision. Elbows sharper than 90 degrees are not included in this standard. For each size of tubing, the length L_s of the straight portions at the ends of an elbow shall not be smaller than indicated in Table 5.2. See Figure 1 for illustration.

Table 5.2
Minimum Dimensions of Elbows

Metric Designator	Radius R to Centerline of Tubing, mm	Length L_s of Each Straight End Portion of Tubing, mm	Trade Size	Radius R to Centerline of Tubing, for reference only (not a requirement) in	Length L_s of Each Straight End Portion of Tubing, in
16	102	38	1/2	4	1-1/2
21	114	38	3/4	4-1/2	1-1/2
27	146	48	1	5-3/4	1-7/8
35	184	51	1-1/4	7-1/4	2
41	210	51	1-1/2	8-1/4	2
53	241	51	2	9-1/2	2
63	267	76	2-1/2	10-1/2	3
78	330	79	3	13	3-1/8
91	381	83	3-1/2	15	3-1/4
103	406	86	4	16	3-3/8

5.5 Expanded-end integral couplings

5.5.1 Electrical metallic tubing may be provided with an integral fitting such as an expanded end. Each such fitting shall comply with the relevant standard for fittings for conduit, tubing, and cable in Reference Item No. 6, Annex A.

6 Test requirements

6.1 Tube

6.1.1 At ambient temperature, one specimen of the smallest available trade size of EMT shall be capable of being bent into a quarter of a circle, without the formation of any cracks in the metal, the opening of seam or weld, or the appreciable distortion of the circular cross-section of the tube. Compliance of tubing with this requirement regarding cracks and openings shall be determined, after bending, by subjecting the tubing to a visual examination.

6.1.2 After being conditioned at a temperature of 0°C (32°F) for 60 min, one specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle using any suitable bending equipment capable of producing elbows with a radious of the curve to the centerline not less than that referenced in Table 5.2. The same specimen may also be used to determine compliance with the coating test in Clause 6.2.1.3. Compliance shall be determined by bending the tube using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2. The tube shall not develop a crack and the weld shall not open. The test shall be conducted inside the cold chamber or shall begin within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below "0°C" ("32°F") shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.1.3 *Deleted*

6.2 Protective coatings

6.2.1 General

6.2.1.1 The protective coating used on the interior or exterior of the tubing shall not crack or flake, as visible using normal or corrected to normal vision, when a finished specimen of the smallest available trade size produced by the manufacturer is tested at ambient temperature. Testing shall be performed by bending the tubing into a semi-circle, using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2.

6.2.1.2 *Deleted*

6.2.1.3 One specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle using any suitable bending equipment capable of producing elbows with a radius of the curve to the centerline not less than that referenced in Table 5.2 being conditioned at a temperature of 0°C (32°F) for 60 min. The tube shall not develop a crack and a weld shall not open. The coatings shall not be damaged to the extent that bare metal is exposed or that the coating separates from the metal. The test shall be conducted inside the cold chamber or begun within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below "0° C" ("32° F") shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.2.1.4 For identification of compounds, a nonmetallic material used as an alternate corrosion-resistant or organic coating shall be subjected to the infrared spectroscopy (IR), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC) tests specified in the applicable standard for polymeric materials. See Reference Item No. 7, Annex A.

6.2.1.5 The supplementary coating described in Clause 5.3.5 need not comply with 6.2.1.1.

6.2.2 Zinc coating

6.2.2.1 A solution of copper sulfate for this test shall be made from distilled water and a reagent grade of cupric sulfate ($CuSO_4$). In a copper container or in a glass, polyethylene, or other chemically nonreactive container in which a bright piece of copper is present, a quantity of the cupric sulfate shall be dissolved in hot distilled water. The purpose is to obtain a solution that has a specific gravity slightly higher than 1.186 after the solution is cooled to a temperature of 18.3°C (65.0°F). Any free acid that might be present shall be neutralized by the addition of approximately 1 gram of cupric oxide (CuO) or 1 gram of cupric hydroxide ($Cu(OH)_2$) per liter of solution. The solution shall then be diluted with distilled water to obtain a specific gravity of exactly 1.186 at a temperature of 18.3°C (65.0°F). The solution shall then be filtered.

6.2.2.2 Several 150-mm (6-in) specimens shall be cut from a sample length of the finished zinc-coated tubing. With prudent attention to the risks to health and to the risk of fire, the specimens shall be cleaned with a suitable organic solvent. Each specimen shall be examined for evidence of damage to the zinc coating, and only specimens that are not damaged shall be selected for use in the test. When a zinc coating is used on the inside and outside of the tubing, half of the specimens shall be longitudinally cut in half to expose the inside surface. If a zinc coating is used only on the outside of the tubing, none of the specimens shall be cut longitudinally.

6.2.2.3 The selected specimens shall be rinsed in water, and all surfaces shall be dried with clean cheesecloth. As much of the water as possible shall be removed in the drying operation because water slows the reaction between the zinc and the solution, thereby adversely affecting the test results. The surface of the zinc shall be dry and clean before a specimen is immersed in the solution of copper sulfate. The specimens shall not be touched by the hands or anything else that can contaminate or damage the surfaces.

Clause 6.2.4.10.2. The coating shall not separate from the metal nor be damaged to the extent that bare metal is exposed.

6.2.4.10.2 The impact test described in Clause 6.2.4.10.1 shall be performed using the Tup B falling mass and the apparatus and method specified in Reference Item No. 18, Annex A. The test shall be conducted inside the cold chamber or within 15 s of removal from the cold chamber.

6.2.4.10.3 Alternatively, a combination of any height and weight that results in the same impact force specified in Clause 6.2.4.10.1 may be used when the impact face remains unchanged.

6.2.4.11 Flammability

6.2.4.11.1 Vertical specimens of finished tubing provided with a nonmetallic alternate corrosion-resistant coating shall not flame for longer than 5 s following any of three 60-s applications of flame, the period between applications being 30 s. A specimen shall not:

a) Emit flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure (flameless charring of the cotton shall be ignored),

b) Continue to flame longer than 5 s after any application of the gas flame, or

c) Have the coating consumed during or after any application of the gas flame.

Note: When an alternate corrosion protection system employs a thin exterior nonmetallic topcoat such as lacquer or paint, measuring less than or equal to 0.125 mm (0.005 in) in thickness, over a confirmed 3 dips worth of zinc, a specimen may display a total consumption of the top coat at the point of flame contact to the conduit without any measurable flame propagation as long as it meets the requirements of 6.2.4.11.1 a) and b). Confirmation of the presence of 3 dips of zinc coating shall be accomplished using the Zinc Coating test, 6.2.2 as part of a separate test.

6.2.4.11.2 This test shall be performed on 3 unaged specimens tested separately, with each positioned 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, and 610 mm (24 in) high, and the top and front shall be open. A 457-mm (18-in) specimen of finished tubing shall be secured with its longitudinal axis vertical in the center of the enclosure. A flat, horizontal layer of untreated surgical cotton 6 – 25 mm (1/4 – 1 in) thick shall cover the floor of the enclosure. The upper surface of the cotton shall be 229 – 241 mm (9 – 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. (This is shown in Figure 4.)

6.2.4.11.3 The burner shall conform to Reference Item No. 19, Annex A, having a bore of 9.5 ±0.3 mm and a length of 100 ±10 mm from the top of the air inlet openings to the top of the mixing tube, or shall be an equivalent that meets the calibration requirements of Reference Item No. 20, Annex A. 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 – 125 mm (4 – 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. 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.

6.2.4.11.4 The gas supply used to supply the burner of Clause 6.2.4.11.3 shall be bottled, technical grade methane or natural gas, approximately 37 MJ/m^3 (1000 Btu/ft^3) at normal pressure, with a suitable regulator and meter for uniform gas flow.

6.2.4.11.5 A wedge, as shown in Figure 5, to which the base of the burner can be secured, shall be provided for tilting the barrel 20 degrees from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The burner shall be secured to the wedge and the assembly shall be placed in an adjustable support jig. A layer of untreated surgical cotton 6 – 25 mm (1/4 – 1 in) thick shall be placed on

Figure 2

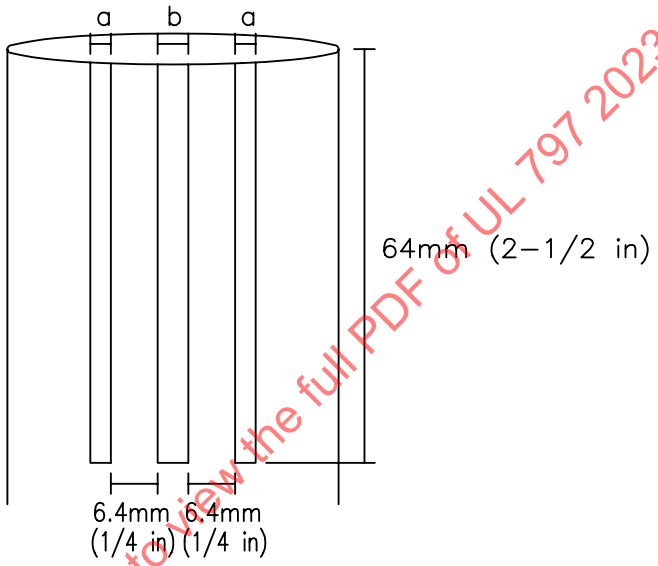
Test apparatus for bending EMT

Figure deleted

Figure 3

Scribe pattern

(See Clause 6.2.4.3.2)



a = 1.3mm (0.050 in) – 2.5mm (0.1 in)
b = 3.2mm (0.125 in) – 5mm (0.2 in)

SM1288C

Annex A (normative)

A.1 Normative references

(See Clause 2.1)

Reference item no.	Clause where referenced	United States	Canada	Mexico
1	1.1	NFPA 70-2017, *National Electrical Code*	CSA C22.1, *Canadian Electrical Code*	NOM-001-SEDE, *Standard for Electrical Installations*
2	1.2	UL 797A *Electrical Metallic Tubing – Aluminum*	CSA C22.2 No. 83, *Electrical Metallic Tubing*	NMX-576-ANCE-2005, *Aluminum Rigid Conduit for Electrical Conductor Protection and Fittings*
3	5.3.3.2	UL 514B *Conduit, Tubing and Cable Fittings*	C22.2 No. 18.3, *Conduit, Tubing and Cable Fittings*	NMX-J-017-ANCE-2005, *Conduit, Tubing and Cable Fittings – Specifications and Test Methods*
4	5.3.5.2	UL 746A *Polymeric Materials – Short Term Property Evaluations*, and UL 514B *Conduit, Tubing and Cable Fittings*	CSA C22.2 No. 0.17-00 (R2018) *Evaluation of Properties of Polymeric Materials*; and CSA C22.2 No. 18.3, *Conduit, Tubing and Cable Fittings*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods* and NMX-J-017-ANCE, *Conduit, Tubing and Cable Fittings – Specifications and Test Methods*
5	5.4.2	UL 514B *Conduit, Tubing and Cable Fittings*	CSA C22.2 No. 18.3, *Conduit, Tubing and Cable Fittings*	NMX-J-017-ANCE-2005, *Conduit, Tubing and Cable Fittings – Specifications and Test Methods*
6	5.5.1	UL 514B *Conduit, Tubing and Cable Fittings*	CSA C22.2 No. 18.3, *Conduit, Tubing and Cable Fittings*	NMX-J-017-ANCE-2005, *Conduit, Tubing and Cable Fittings – Specifications and Test Methods*
7	6.2.1.4	UL 746A *Polymeric Materials – Short Term Property Evaluations*	CSA C22.2 No. 0.17-00 (R2018), *Evaluation of Properties of Polymeric Materials*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*
8	6.2.2.11	ASTM A 239-95 (2004), *Standard Practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles*	ASTM A 239-95 (2004), *Standard Practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles*	NMX-H-013-1984, *Coating – Zinc – Locating the Thinnest Spot on Galvanized Steel Articles – Test Method (Preece Test)*
9	6.2.4.1	UL 514B*Conduit, Tubing and Cable Fittings*	CSA C22.2 No. 18.3, *Conduit, Tubing and Cable Fittings*	NMX-J-017-ANCE-2005, *Conduit, Tubing and Cable Fittings – Specifications and Test Methods*
10	6.2.4.5.2	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*
11	6.2.4.5.3	ASTM G 153-04, *Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*	ASTM G 153-04, *Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*
12	6.2.4.5.4	ASTM G 155-05, *Cycle 1, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*	ASTM G 155-05, *Cycle 1, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*

Reference item no.	Clause where referenced	United States	Canada	Mexico
13	6.2.4.6.1	ASTM B 117-03, *Standard Practice for Operating Salt Spray (Fog) Apparatus*	ASTM B 117-03, *Standard Practice for Operating Salt Spray (Fog) Apparatus*	NMX-D-022-1973, *Method of Test for Corrosion – Resistance of Coated Metal Parts Used in Motor Vehicles Salt Spray (Fog) Method*
14	6.2.4.6.2	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*
15	6.2.4.7.2	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	ASTM D 1654-05, *Procedure A, Method 2, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*	NMX-J-023/1-ANCE-2000, *Electrical Products – Metallic Outlet Boxes Part 1: Specifications and Test Methods*
16	6.2.4.8.1	ASTM D 638-03, *Standard Test Method for Tensile Properties of Plastics*	ASTM D 638-03, *Standard Test Method for Tensile Properties of Plastics*	NMX-E-082-2002, *Plastic Industry-Tensile Strength of Plastic Materials-Test Methods*
17	6.2.4.9.2	ASTM D 3359-02, *Standard Test Methods for Measuring Adhesion by Tape Test*	ASTM D 3359-02, *Standard Test Methods for Measuring Adhesion by Tape Test*	NMX-H-013-1984, *Coating – Zinc – Locating the Thinnest Spot on Galvanized Steel Articles – Test Method (Preece Test)*
18	6.2.4.10.2	ASTM D 2444-99 (R2005), *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*	ASTM D 2444-99 (R2005), *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*	NMX-E-012-SCFI-1999, *Plastics Industry – Pipes and Connections – PVC Pipes and Connections without Plastification for Electrical Installations – Specifications*
19	6.2.4.11.3	ASTM D 5025-05, *Standard Specification of Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*	ASTM D 5025-05, *Standard Specification of Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*	NMX-J-192-ANCE-1999, *Electrical Products – Wires and Cables – Flame Test on Electrical Cables – Test Methods*
20	6.2.4.11.3	ASTM D 5207-03, *Standard Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials*	ASTM D 5207-03, *Standard Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials*	NMX-J-192-ANCE-1999, *Electrical Products – Wires and Cables – Flame Test on Electrical Cables – Test Methods*

ASME: American Society of Mechanical Engineers

ASTM: American Society for Testing and Materials

NFPA: National Fire Protection Association

Update No. 1
C22.2 No. 83.1-07
December 2012

Note: *For information about the* ***Standards Update Service****, go to* ***shop.csa.ca*** *or e-mail* ***techsupport@csagroup.org.***

Title: *Electrical Metallic Tubing — Steel* — originally published November 2007

The following revisions have been formally approved and are marked by a vertical line in the margin on the attached replacement pages:

Revised	Title page, copyright page, Contents, and Preface
New	Clauses 7.8 and 7.9 and Annex F
Deleted	None

- Update your copy by inserting these revised pages.
- Keep the pages you remove for reference.

Association of Standardization and Certification
NMX-J-536-ANCE
Third Edition

CSA Group
CSA C22.2 No. 83.1-07
Second Edition

Underwriters Laboratories Inc.
UL 797
Ninth Edition

Electrical Metallic Tubing – Steel

November 30, 2007

(Title Page Reprinted: December 21, 2012)

ANSI/UL 797-2012

Commitment for Amendments

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

ISBN 978-1-55436-521-0 © 2007 CSA Group

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

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This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through December 21, 2012. The most recent designation of ANSI/UL 797 as an American National Standard (ANSI) occurred on December 21, 2012. 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 797 on January 25, 1982. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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The interpretation by the standards development organization of an identical or equivalent standard is to be 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.

ANCE effective date

The effective date for ANCE will be announced through the Diario Oficial de la Federación (Official Gazette) and is indicated on the cover page.

CSA Group effective date

The effective date for CSA Group will be announced through *CSA Informs* or a *CSA Group Certification Notice*.

UL effective date

As of December 21, 2012, all products Listed or Recognized by UL must comply with the requirements in this standard except for Clauses 7.8, 7.9, and Annex F (Clause F.1 and Table F1) which are effective June 21, 2014.

A UL effective date is established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Electrical Metallic Tubing – Steel

1 Scope

1.1 These requirements cover electrical metallic tubing – steel (EMT) and elbows for use as a metal raceway for installation of wires and cables in accordance with CSA C22.1, Canadian Electrical Code, Part 1, NOM-001-SEDE, Standard for Electrical Installations, and NFPA 70, National Electrical Code (see Reference Item No. 1, Annex A). EMT is provided with a zinc, zinc-based, nonmetallic, or other alternate corrosion-resistant exterior coating and an organic or zinc interior coating. It is the users' responsibility to determine the appropriate product for their application.

1.2 Aluminum electrical metallic tubing is covered by the standards listed in Reference Item No. 2, Annex A.

2 Normative references

2.1 Products covered by this standard shall comply with the reference installation codes and standards as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used. A ″Reference Item No.″ is provided at the point of use for each reference in this standard. See Annex A for a list of reference publications and the correlating list of reference item numbers to applicable country publications.

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

3 Definitions

3.1 The following definitions apply in this standard.

3.2 Coating(s), alternate corrosion-resistant. A primary coating(s) other than one consisting solely of zinc, which upon evaluation has demonstrated the ability to provide the level of corrosion resistance required on the exterior of tubing. See Clause 6.2.4.

Note: Coating(s) may include zinc.

3.3 Coating(s), organic. An interior coating(s), other than one consisting solely of zinc, which, upon evaluation, has demonstrated the ability to provide the level of corrosion resistance necessary where the coating is not subject to physical damage. See Clause 6.2.3.

Note: Coating(s) may include zinc.

3.4 Coating(s), zinc. A primary coating consisting solely of zinc, which, upon evaluation, has demonstrated the ability to provide the level of corrosion resistance required on the exterior of the tubing. See Clause 6.2.2.

3.5 Elbow. A manufactured curved section of EMT.

6.2.4.11.6 In the absence of a gas pilot light on the burner, the support for the burner and wedge shall be arranged to enable the burner to be quickly removed from and precisely returned to the position described in Clause 6.2.4.11.5 without disturbing the layer of cotton on the floor of the enclosure or the cotton on the wedge and around the base of the burner.

6.2.4.11.7 In instances where the burner has a gas pilot light, the valve supplying gas to the pilot shall be opened and the pilot lit. Where the burner does not have a gas pilot light, the burner shall be supported as indicated in Clause 6.2.4.11.6 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 without drafts that affect the flame.

6.2.4.11.8 When 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 60 s and then closed for 30 s. This procedure shall be repeated twice for a total of 3 applications of flame to the specimen.

7 Markings

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

7.1 Each finished straight length of EMT and each factory elbow shall be marked with the manufacturer's name, the trade name for the product, or both, or any other distinctive marking by means of which the organization responsible for the product can readily be identified.

7.2 In the United States, when the tubing and elbows are produced in more than one factory, each finished length of tubing and each elbow shall have a distinctive marking by means of which it can be identified as the product of a particular factory. This marking may be in code.

In Canada and Mexico, this requirement does not apply.

7.3 Each straight length of tubing and each elbow shall be legibly marked ″Electrical Metallic Tubing″ or ″EMT″ by a durable means such as by die stamping, ink stamping with etching ink, or paint. This marking shall be in letters at least 3 mm (1/8 in) high.

7.4 Each finished length of tubing or elbow shall be legibly and durably marked ″Consult manufacturer for proper installation″ or equivalent wording.

7.5 Tubing provided with a nonmetallic alternate corrosion-resistant coating shall be allowed to be marked with a maximum use temperature of ″90°C″ (″200°F″). Tubing tested for use at maximum ambient temperature higher than 90°C (200°F) shall be marked ″____°C″ (″____°F″) with the rated temperature as evaluated in Clause 6.2.4.4.1. The tubing shall be marked at a minimum of once every 3.05 m (10 ft) and no less than once every piece.

7.6 Tubing provided with a nonmetallic alternate corrosion-resistant coating shall be allowed to be marked with a minimum use temperature of ″0°C″ (″32°F″). Tubing tested for use at a minimum ambient temperature below 0°C (32°F) shall be marked ″____°C″ (″____°F″) with the rated temperature as evaluated in Clause 6.2.1.3. The tubing shall be marked at a minimum of once every 3.05 m (10 ft) and no less than once every piece.

7.7 Tubing or elbows provided with a supplementary coating or coatings that have not been evaluated for furnishing corrosion protection for the tube shall be marked ″Corrosion protection properties of the _____ coating were not investigated″ or equivalent wording. The blank shall be filled in with the type of supplementary coating.

7.8 Each master bundle tag for tubing, see Annex F, or carton/package for elbows shall have a distinctive marking that indicates the date or other dating period of manufacture not exceeding any three consecutive months. For an elbow or bend, the date of manufacture shall be the date that:

a) The tube is made and the bending occurs at the same location, or

b) The elbow or bend was formed, when the tubing is made at a different location.

7.9 The date of manufacture may be abbreviated in a nationally accepted conventional code or in a code affirmed by the manufacturer if the code does not:

a) Repeat in less than 20 years, and

b) Require reference to the production records of the manufacturer to determine when the product was manufactured.

Annex E (informative)

E.1 Alternative National Markings

(See Clause 7)

E1.1 Products intended for use in specific national applications may bear the following alternative markings to those specified in Clause 7 of the Standard.

Table E1
Alternative National Markings

Clause	English	Spanish	French
7.3	Electrical Metallic Tubing	Tubo metálico rígido de acero tipo ligero	Tube électrique métallique
7.4	Consult manufacturer for proper installation	Consultar con el fabricante sobre los requisitos de instalación	Consulter les directives d'installation du fabricant
7.7	Corrosion protection properties of the ____ coating were not investigated	Las propiedades de la cubierta de____ para la protección contra la corrosión no ha sido sometidas a pruebas	Le degré de protection contre la corrosion du revêtement ____ n'a pas été étudié

Annex F (informative)

F.1 Master Bundle Quantity

(See Clauses 7.8 and 7.9)

Table F1
Master bundle quantity – 3.05-m (10-foot) lengths

Trade size	(Metric designator)	Pieces	Feet	(Meters)	Nominal Wt/Lbs	(Wt/kg)
1/2	16	700	7000	2133.6	2100	948.0
3/4	21	500	5000	1524	2300	1037.8
1	27	300	3000	914.4	2010	916.3
1-1/4	35	200	2000	609.6	2020	911.7
1-1/2	41	150	1500	457.2	1740	789.2
2	53	120	1200	365.8	1776	807.4
2-1/2	63	61	610	185.9	1318	598.7
3	78	51	510	155.4	1341	607.8
3-1/2	91	37	370	112.8	1291	585.1
4	103	30	300	91.4	1179	535.2

Standards Update Service

CSA C22.2 No. 83.1:07
November 2007

Title: *Electrical Metallic Tubing — Steel*

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National Association of Standardization and Certification of the Electrical Sector
NMX-J-536-ANCE-2007
Second Edition

Canadian Standards Association
CSA C22.2 No. 83.1-07
Second Edition

Underwriters Laboratories Inc.
UL 797
Ninth Edition

Electrical Metallic Tubing – Steel

November 30, 2007

ANSI/UL 797-2007

Commitment for Amendments

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

ISBN 978-1-55436-521-0

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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. 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 http://csds.ul.com.

The most recent designation of ANSI/UL 797 as an American National Standard (ANSI) occurred on November 27, 2007. The ANSI approval for this standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface.

This ANSI/UL Standard for Safety, which consists of the Ninth edition, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

The U.S. Department of Defense (DoD) has adopted UL 797 on January 25, 1982. The publication of revisions or a new edition of this standard will not invalidate the DoD adoption.

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B. Haydon	Canadian Standards Association, Mississauga, Ontario	*Project Manager*

CONTENTS

Preface

This is the common ANCE, CSA, and UL standard for electrical metallic tubing – steel. It is the second edition of NMX-J-536-ANCE-2007, the second edition of CSA C22.2 No. 83.1, and the ninth edition of UL 797. This edition of CSA C22.2 No. 83.1 supersedes the previous edition published in 2004. This edition of UL 797 supersedes the previous edition published June 30, 2004.

This common standard was prepared by the Association of Standardization and Certification (ANCE), Canadian Standards Association (CSA), and Underwriters Laboratories Inc. (UL), and the conduit manufacturing industry. The efforts and support of the Technical Harmonization Subcommittee for Conduit and Tubing, of the Council of 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.

This standard was reviewed by the CSA Subcommittee on Metal Conduit and Tubing, 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 Technical Committee.

This standard will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

This standard has been approved by the American National Standards Institute as an American National 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 an IEC format, but is not based on, nor is it to be considered equivalent to an IEC standard. This standard is published as an equivalent standard for ANCE, CSA, and UL. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical deviations are allowed for codes and governmental regulations and 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 to be word for word except for editorial changes.

Reasons for differences from IEC

The Technical Harmonization Subcommittee identified several IEC standards that address electrical conduit and tubing included in the scope of this standard. The IEC standards for electrical conduit and tubing are recognized as being generally system-specific, containing the requirements for the relevant conduits, tubing, and associated fittings in several discrete IEC standards.

The THSC determined the safe use of electrical conduit and tubing is dependent on the design and performance of the conduit and tubing 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 electrical conduit and tubing and associated fittings with those presently addressed in the known IEC standards. The THSC agreed such future investigation might be facilitated by completion of harmonization of the North American standards for electrical conduit and tubing and their fittings.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is to be 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.

ANCE effective date

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CSA effective date

The effective date for CSA International will be announced through CSA Informs or a CSA Certification Notice.

UL effective date

As of November 30, 2007 all products Listed or Recognized by UL must comply with the requirements in this standard.

A UL effective date is established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Electrical Metallic Tubing – Steel

1 Scope

1.1 These requirements cover electrical metallic tubing – steel (EMT) and elbows for use as a metal raceway for installation of wires and cables in accordance with CSA C22.1, Canadian Electrical Code, Part 1, NOM-001-SEDE, Standard for Electrical Installations, and NFPA 70, National Electrical Code (see Reference Item No. 1, Annex A). EMT is provided with a zinc, zinc-based, nonmetallic, or other alternate corrosion-resistant exterior coating and an organic or zinc interior coating. It is the users' responsibility to determine the appropriate product for their application.

1.2 Aluminum electrical metallic tubing is covered by the standards listed in Reference Item No. 2, Annex A.

2 Normative references

2.1 Products covered by this standard shall comply with the reference installation codes and standards as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used. A ″Reference Item No.″ is provided at the point of use for each reference in this standard. See Annex A for a list of reference publications and the correlating list of reference item numbers to applicable country publications.

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

3 Definitions

3.1 The following definitions apply in this standard.

3.2 Coating(s), alternate corrosion-resistant. A primary coating(s) other than one consisting solely of zinc, which upon evaluation has demonstrated the ability to provide the level of corrosion resistance required on the exterior of tubing. See Clause 6.2.4.

Note: Coating(s) may include zinc.

3.3 Coating(s), organic. An interior coating(s), other than one consisting solely of zinc, which, upon evaluation, has demonstrated the ability to provide the level of corrosion resistance necessary where the coating is not subject to physical damage. See Clause 6.2.3.

Note: Coating(s) may include zinc.

3.4 Coating(s), zinc. A primary coating consisting solely of zinc, which, upon evaluation, has demonstrated the ability to provide the level of corrosion resistance required on the exterior of the tubing. See Clause 6.2.2.

3.5 Elbow. A manufactured curved section of EMT.

3.6 Electrical metallic tubing – steel (EMT). An unthreaded steel raceway of circular cross-section designed for the physical protection and routing of wire conductors and for use as an equipment grounding conductor when installed utilizing appropriate fittings.

3.7 Primary coating. A coating on the outside of the tubing for protection against corrosion. See Clause 5.3.1.1.

3.8 Supplementary coating. A coating on the outside of the tubing in addition to the primary coating, for protection against severe corrosive conditions. See Clause 5.3.5.

4 Units of measurement

4.1 In Canada and Mexico, the values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

In the United States, the values stated in either SI units or inch-pound units shall be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems can result in nonconformance with the standard.

5 Construction

5.1 Tube

5.1.1 Each tube shall be of steel, shall be straight, and shall have a circular cross-section. All seams shall be thoroughly welded.

5.1.2 A welded seam shall not have metal trimmings, sharp edges, or sharp projections on the interior or exterior surfaces of the tube. A slight bead on the interior wall at the weld line shall be allowed if the bead is not sharp and if the bead does not exceed 0.38 mm (0.015 in) in height for the trade size 16 – 53 (1/2 – 2) or 0.51 mm (0.020 in) in height for the trade size 63 – 103 (2-1/2 – 4).

5.1.3 Before the protective coating is applied, the interior and exterior surfaces of each tube shall be free from scale, flash, or any other protrusion, other than as specified in Clause 5.1.2.

5.1.4 The end of the tubing shall be cut off squarely and shall be without any burrs and sharp edges.

5.1.5 Electrical metallic tubing shall not be threaded unless the integral fittings mentioned in Clause 5.5 are steel, and the thread is not of the standard pipe-thread dimensions.

5.2 Finished tubing

5.2.1 The outside diameter and the minimum weight of finished electrical metallic tubing shall be as indicated in Table 5.1. The standard length of electrical metallic tubing shall be 3.05 m (10 ft) ±6 mm (±1/4 in). Each length of EMT shall be examined visually on both exterior and interior surfaces to determine the absence or presence of poor coatings, hard scale, burrs or fins, or other defects. See Annex D.

5.2.2 Lengths, other than standard lengths, shall have a minimum acceptable weight proportional to the weights specified in Table 5.1. The length tolerances in Clause 5.2.1 shall be applicable for non-standard lengths.

Table 5.1
Dimensions and Weights

Metric designator	Outside diameter, mm	Minimum acceptable weight, kg/m	Trade size	Outside diameter, in	Minimum acceptable weight, lbs/ft
16	17.93 ± 0.13	0.424	1/2	0.706 ± 0.005	0.285
21	23.42 ± 0.13	0.647	3/4	0.922 ± 0.005	0.435
27	29.54 ± 0.13	0.952	1	1.163 ± 0.005	0.640
35	38.35 ± 0.13	1.414	1-1/4	1.510 ± 0.005	0.950
41	44.20 ± 0.13	1.637	1-1/2	1.740 ± 0.005	1.10
53	55.80 ± 0.13	2.083	2	2.197 ± 0.005	1.40
63	73.03 ± 0.25	3.051	2-1/2	2.875 ± 0.010	2.05
78	88.90 ± 0.38	3.720	3	3.500 ± 0.015	2.50
91	101.60 ± 0.50	4.837	3-1/2	4.000 ± 0.020	3.25
103	114.30 ± 0.50	5.506	4	4.500 ± 0. 020	3.70

5.2.3 Other dimensions of EMT complying with the requirements in this standard are provided in Annex B for information only.

5.3 Protective coatings

5.3.1 General

5.3.1.1 The exterior surface of EMT shall be protected against corrosion by a coating solely of zinc, as described in Clause 5.3.2, or an alternate corrosion-resistant coating, as described in Clause 5.3.3. The interior surface of the tubing shall be protected against corrosion by a coating of zinc or an organic coating, as described in Clauses 5.3.2 and 5.3.4 respectively. See Annex C for an overview.

5.3.2 Zinc coating

5.3.2.1 A protective coating of zinc shall cover completely, shall adhere firmly at all points, shall be smooth and free from blisters and other defects that can lessen the protective value of the coating, shall be in metal-to-metal contact with the steel, and shall comply with Clause 6.2.2.

5.3.3 Alternate corrosion-resistant coating

5.3.3.1 An alternate corrosion-resistant coating shall cover completely, shall adhere firmly at all points, and shall be smooth and free from blisters and other defects that can lessen the protective value of the coating.

5.3.3.2 An alternate corrosion-resistant coating shall comply with the requirements of Clause 6.2.4. The tubing or elbow shall be subjected to the assembly, bending, resistance, pull, and fault current tests in accordance with Reference Item No. 3, Annex A, with both set-screw and compression type couplings, without removal of the alternate corrosion-resistant coating.

5.3.3.3 Tubing provided with a nonmetallic alternate corrosion-resistant coating that is not marked with a temperature designation, or is marked ″90°C″ (“200°F”), is for use in ambient temperatures that do not exceed 90°C (200°F). It is not prohibited that tubing provided with a nonmetallic alternate corrosion-resistant coating that is for use at temperatures in excess of 90°C (200°F) be marked with a rating that has been evaluated in accordance with Clause 6.2.4.4.1.

5.3.3.4 Tubing provided with a nonmetallic alternate corrosion-resistant coating that is not marked with a temperature designation, or is marked ″0°C″ (“32°F”), is for use in ambient temperatures not below 0°C (32°F). It is not prohibited that tubing provided with a nonmetallic alternate corrosion-resistant coating that is for use at temperatures below 0°C (32°F) be marked with a rating that has been evaluated in accordance with Clauses 6.2.1.3 and 6.2.4.10.

5.3.4 Organic coating

5.3.4.1 An organic coating shall cover evenly the surface to which it is applied, shall be of uniform quality throughout, shall have a smooth and even appearance, and shall comply with Clause 6.2.3 and the bending requirements of Clause 6.2.1.1.

5.3.5 Supplementary coating

5.3.5.1 The use of one or more supplementary coatings is not prohibited. The supplementary coating or coatings are not required to meet the requirements for primary corrosion-resistant coatings. Tubing or elbows that are provided with supplementary coatings that have not been evaluated for their corrosion resistance characteristics shall be marked in accordance with Clause 7.7.

5.3.5.2 Supplementary nonmetallic coatings shall be evaluated with respect to:

a) flame propagation,

b) detrimental effects on the corrosion resistance provided by the primary protective coatings,

c) the fit of the couplings, and

d) electrical continuity with couplings.

See Reference Item No. 4, Annex A. The supplementary coating shall be provided in addition to the full primary corrosion-resistant coating.

5.3.6 Surface treatment

5.3.6.1 When one or more surface treatments not exceeding 0.0038 mm (0.00015 in) are employed as a top coat or conversion coating, the coatings shall not be required to meet the requirements for an alternate corrosion-resistant coating or organic coating.

5.4 Elbows

5.4.1 Elbows shall be made from the same grade of tubing as that used for straight lengths of EMT and shall be treated, coated, and otherwise produced according to the requirements for EMT. See Annex D.

5.4.2 An elbow may be provided with an integral coupling or other integral fitting on one or both ends. Each fitting shall comply with Reference Item No. 5, Annex A.

5.4.3 No elbow shall be sharper than 90 degrees. Tolerances for elbows shall be plus or minus 2 degrees. For each size of tubing, the radius R and the length L_s of the straight portions at the ends of an elbow shall not be smaller than indicated in Table 5.2. See Figure 1 for illustration.

Table 5.2
Minimum Dimensions of Elbows

Metric Designator	Radius R to Centerline of Tubing, mm	Length L_s of Each Straight End Portion of Tubing, mm	Trade Size	Radius R to Centerline of Tubing, in	Length L_s of Each Straight End Portion of Tubing, in
16	102	38	1/2	4	1-1/2
21	114	38	3/4	4-1/2	1-1/2
27	146	48	1	5-3/4	1-7/8
35	184	51	1-1/4	7-1/4	2
41	210	51	1-1/2	8-1/4	2
53	241	51	2	9-1/2	2
63	267	76	2-1/2	10-1/2	3
78	330	79	3	13	3-1/8
91	381	83	3-1/2	15	3-1/4
103	406	86	4	16	3-3/8

5.5 Expanded-end integral couplings

5.5.1 Electrical metallic tubing may be provided with an integral fitting such as an expanded end. Each such fitting shall comply with the relevant standard for fittings for conduit, tubing, and cable in Reference Item No. 6, Annex A.

6 Test requirements

6.1 Tube

6.1.1 At ambient temperature, one specimen of the smallest available trade size of EMT shall be capable of being bent into a quarter of a circle, without the formation of any cracks in the metal, the opening of seam or weld, or the appreciable distortion of the circular cross-section of the tube. Compliance of tubing with this requirement regarding cracks and openings shall be determined, after bending, by subjecting the tubing to a visual examination.

6.1.2 After being conditioned at a temperature of 0°C (32°F) for 60 min, one specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle around a mandrel. The same specimen may also be used to determine compliance with the coating test in Clause 6.2.1.3. Compliance shall be determined by bending the tube with the test apparatus as shown in Figure 2 with a radius as described in Table 5.2. The tube shall not develop a crack and the weld shall not open. The test shall be conducted inside the cold chamber or shall begin within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below ″0°C″ (″32°F″) shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.1.3 Compliance of trade sizes 16 (1/2), 21 (3/4), and 27 (1) EMT with the requirements in Clauses 6.1.1 and 6.1.2 shall be determined by bending the tube with the test apparatus as shown in Figure 2 with a radius as described in Table 5.2. Compliance of EMT larger than trade size 27 (1) with the requirements in Clauses 6.1.1 and 6.1.2 shall be determined by bending the tube with any suitable bending equipment that has a radius as described in Table 5.2.

6.2 Protective coatings

6.2.1 General

6.2.1.1 The protective coating used on the interior or exterior of the tubing shall not crack or flake, as visible using normal or corrected to normal vision, when a finished specimen of the smallest available trade size produced by the manufacturer is tested at ambient temperature. Testing shall be performed by bending the tubing into a semi-circle, the centerline of which has a radius as described in Table 5.2.

6.2.1.2 Compliance of trade sizes 16 (1/2), 21 (3/4), and 27 (1) EMT with the requirement in Clause 6.2.1.1 shall be determined by bending the tube with the test apparatus as shown in Figure 2. Compliance of EMT larger than trade size 27 (1) with the requirement in Clause 6.2.1.1 shall be determined by bending the tube with any suitable bending equipment.

6.2.1.3 One specimen of the smallest available trade size of finished tube shall be capable of being bent into a quarter of a circle around a mandrel after being conditioned at a temperature of 0°C (32°F) for 60 min. Compliance shall be determined by bending the tube with the test apparatus as shown in Figure 2 with a radius as described in Table 5.2. The coatings shall not be damaged to the extent that bare metal is exposed or that the coating separates from the metal. The test shall be conducted inside the cold chamber or begun within 15 s of removal from the cold chamber. Tubing that is provided with a nonmetallic alternate corrosion-resistant coating and that is marked with a temperature rating below ″0°C″ (″32°F″) shall be conditioned at the rated temperature. The rated temperature shall be any temperature below 0°C (32°F) in 5°C (9°F) increments.

6.2.1.4 For identification of compounds, a nonmetallic material used as an alternate corrosion-resistant or organic coating shall be subjected to the infrared spectroscopy (IR), thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC) tests specified in the applicable standard for polymeric materials. See Reference Item No. 7, Annex A.

6.2.2 Zinc coating

6.2.2.1 A solution of copper sulfate for this test shall be made from distilled water and a reagent grade of cupric sulfate ($CuSO_4$). In a copper container or in a glass, polyethylene, or other chemically nonreactive container in which a bright piece of copper is present, a quantity of the cupric sulfate shall be dissolved in hot distilled water. The purpose is to obtain a solution that has a specific gravity slightly higher than 1.186 after the solution is cooled to a temperature of 18.3°C (65.0°F). Any free acid that might be present shall be neutralized by the addition of approximately 1 gram of cupric oxide (CuO) or 1 gram of cupric hydroxide ($Cu(OH)_2$) per liter of solution. The solution shall then be diluted with distilled water to obtain a specific gravity of exactly 1.186 at a temperature of 18.3°C (65.0°F). The solution shall then be filtered.

6.2.2.2 Several 150-mm (6-in) specimens shall be cut from a sample length of the finished zinc-coated tubing. With prudent attention to the risks to health and to the risk of fire, the specimens shall be cleaned with a suitable organic solvent. Each specimen shall be examined for evidence of damage to the zinc coating, and only specimens that are not damaged shall be selected for use in the test. When a zinc coating is used on the inside and outside of the tubing, half of the specimens shall be longitudinally cut in half to expose the inside surface. If a zinc coating is used only on the outside of the tubing, none of the specimens shall be cut longitudinally.

6.2.2.3 The selected specimens shall be rinsed in water, and all surfaces shall be dried with clean cheesecloth. As much of the water as possible shall be removed in the drying operation because water slows the reaction between the zinc and the solution, thereby adversely affecting the test results. The surface of the zinc shall be dry and clean before a specimen is immersed in the solution of copper sulfate. The specimens shall not be touched by the hands or anything else that can contaminate or damage the surfaces.

6.2.2.4 A glass, polyethylene, or other chemically nonreactive beaker having a diameter equal to approximately twice the diameter measured over the specimen shall be filled with the solution of copper sulfate to a depth of not less than 76 mm (3 in). The temperature of the solution shall be maintained at 18.3 ±1.1°C (65.0 ±2.0°F). The specimen shall be immersed in the solution and supported on end in the center of the beaker so that not less than 64 mm (2-1/2 in) of its length is immersed. The specimen shall remain in the solution for 60 s, during which time it shall not be moved, nor shall the solution be stirred.

6.2.2.5 At the end of the 60 s period, the specimen shall be removed from the beaker, rinsed immediately in running tap water, rubbed with clean cheesecloth until any loosely adhering deposits of copper are removed, and then dried with clean cheesecloth. Again, hands and other damaging and contaminating objects and substances shall not touch the surfaces that were immersed. The part of the specimen that was immersed shall be examined, considering each broad surface separately and disregarding the portions of the specimen within 13 mm (1/2 in) of the cut ends on sizes 12 – 53 (3/8 – 2) and 25 mm (1 in) for sizes 63 – 103 (2-1/2 – 4) and within 3 mm (1/8 in) of any longitudinal edges cut in the process of preparing the specimen.

6.2.2.6 A record shall be made when the immersed part of the specimen has any deposit of bright, firmly-adhering copper exclusive of the 13 mm (1/2 in) cut-end portions and any 3 mm (1/8 in) longitudinal cut-edge portions.

6.2.2.7 When bright adhering copper is not found, the process of immersing, washing, rubbing, drying, examining, and recording shall be repeated up to the required number of immersions, or until the presence of copper is noted, whichever comes first, using the same specimen and beaker of solution. After the dips are completed on any one specimen, the portion of the solution of copper sulfate used shall be discarded. A fresh portion of the solution shall be employed for each of any succeeding specimens.

6.2.2.8 A protective zinc coating that provides the sole means of primary corrosion resistance on the exterior of the tubing shall be such that a specimen of the finished tubing does not show a bright, adherent deposit of copper after four 60-s immersions in a copper sulfate solution.

6.2.2.9 A protective zinc coating that provides the sole means of primary corrosion resistance on the interior of the tubing shall be such that a specimen of the finished tubing does not show a bright, adherent deposit of copper after one 60-s immersion in a copper sulfate solution.

6.2.2.10 When it is desired to show the character of the bright metallic copper deposit on an exposed steel surface, prepare a reference standard for comparison as follows. Partially submerge a zinc-coated specimen in strong hydrochloric acid until a violent action ceases. Immediately remove the specimen, wash, and wipe it dry. Then dip the specimen, with an area of bare surface thus exposed, including a portion with zinc coating intact, for a few seconds in the copper sulfate solution at a temperature of 16 – 20°C (61 – 66°F), remove it, wash it, and wipe it dry. Prepare this copper-coated reference standard at the time of testing.

6.2.2.11 For an alternate test method to the one described in Clauses 6.2.2.1 – 6.2.2.10, see Reference Item No. 8, Annex A.

6.2.3 Organic coatings

6.2.3.1 Elasticity test

6.2.3.1.1 The organic coating used to protect the interior of the tubing, when applied to a sheet-steel test piece and baked in an oven for 5 h, shall withstand without damage 10 successive bends of the test piece back and forth through an angle of 180 degrees against an edge having a radius of 1.6 mm (1/16 in).

6.2.3.1.2 The apparatus shall consist of flat test pieces of sheet steel 75 by 125 mm (3 by 5 in) long and approximately 0.25 mm (0.010 in) thick, an oven for baking the test pieces, and a vise with jaws at least 75 mm (3 in) wide for holding the test pieces during the bending test. The 75-mm (3-in) edge of each jaw shall be rounded to a radius of 1.6 mm (1/16 in).

6.2.3.1.3 Two test pieces shall be cleaned with a suitable organic solvent to remove any grease and foreign material and shall then be dipped in the organic coating. After air drying for 30 min, the test pieces shall be suspended by means of short wires in the oven. The test pieces shall be baked for 5 h at the normal baking temperature for the coating in question, but if the normal baking temperature is lower than 135°C (275°F) or if the coating is regularly air dried, the oven temperature shall be maintained at 135 – 150°C (275 – 302°F).

6.2.3.1.4 At the end of the 5 h, the test pieces shall be removed from the oven and cooled in still air to room temperature. Each flat test piece shall be secured in the vise, gripped at its free end, and then bent for 90 degrees against one of the 75-mm (3-in) edges of the vise jaws. Each test piece shall then be bent back past its original position, through 180 degrees, so that it ends bent 90 degrees against the other 75-mm (3-in) edge of the vise jaws. It shall then be bent for 90 degrees in the opposite direction, ending with the test piece in its original position. This cycle shall be repeated 5 times. The organic coating shall not be accepted if the coating on any test piece cracks, flakes off, or is damaged otherwise.

6.2.3.2 Warm humid air test

6.2.3.2.1 The test apparatus shall be an insulated specimen chamber with inside dimensions approximately 119 by 71 by 71 cm (47 by 28 by 28 in). It shall contain a temperature-controlled water reservoir, pump, and spray chamber for humidifying the air, an air-circulating fan, provision for heating the air, specimen supports, and the necessary means of control.

6.2.3.2.2 The dry bulb temperature of the test chamber shall be maintained at 60 ±1°C (140 ±2°F) and at 98 ±2% relative humidity throughout the test. The specimens shall be supported in racks at an angle of 15 degrees from the vertical.

6.2.3.2.3 The test shall be conducted for a period of 60 d, at the end of which there shall not be any corrosion of the metal.

6.2.4 Alternate corrosion-resistant coatings

6.2.4.1 A coating other than one consisting solely of zinc, which is to be evaluated for its ability to provide corrosion resistance on the exterior of tubing, shall, in addition to the requirements in Clauses 6.2.4.2 – 6.2.4.7.3, be evaluated with respect to flame propagation. See Clause 6.2.4.11. Additionally the tubing or elbow shall be subjected to the assembly, bending, resistance, pull, and fault current tests in accordance with Reference Item No. 9, Annex A, with both set-screw and compression-type couplings.

6.2.4.2 The coating shall comply with the salt-spray (fog), moist carbon dioxide-sulfur dioxide-air, and ultraviolet light and water tests after being conditioned in accordance with Clause 6.2.4.4. Corrosion within 13 mm (1/2 in) of cut edges shall be disregarded.

6.2.4.3 Preparation of specimens

6.2.4.3.1 Thirty 152 – 203 mm (6 – 8 in) long specimens, provided with the corrosion-resistant coating, of trade size 2 (53), or the closest trade size manufactured, shall be tested.

6.2.4.3.2 Half of the specimens to be exposed shall be scribed using a rotary tool operating at a speed of 15,000 – 30,000 rpm. The specimens shall be scribed in accordance with Figure 3 using a 1.14 mm (0.045 in) thick fiberglass reinforced cut-off wheel until bright base metal is exposed. The specimens shall be free of grease or dirt. The coating thickness of each specimen shall be measured prior to exposing it to the test environments.

6.2.4.4 Air oven conditioning exposure

6.2.4.4.1 Six scribed and six unscribed specimens of each coating shall be conditioned for 240 h at a temperature of 100 ±1°C (212 ±2°F) in an air-circulating oven. Tubing that is marked with a temperature rating above 90°C (200°F) shall be conditioned at the rated temperature plus 10°C (18°F), for which the rated temperature shall be any temperature in excess of 90°C (200°F) at 25°C (45°F) increments. These specimens shall be used for the resistance to salt spray (fog) (Clauses 6.2.4.6.1 and 6.2.4.6.2) and the resistance to moist carbon dioxide-sulfur dioxide-air (Clauses 6.2.4.7.1 – 6.2.4.7.3) tests.

6.2.4.5 Resistance to ultraviolet light and water

6.2.4.5.1 Three scribed and three unscribed specimens shall be exposed to ultraviolet light and water by either of the methods specified in Clause 6.2.4.5.3 or 6.2.4.5.4.

6.2.4.5.2 As a result of the exposure, the unscribed specimens shall not show any base metal corrosion or any blisters. For the scribed specimens, the average creeping distance of red rust from the scribe shall not be greater than Rating No. 6 (1.6 – 3.2 mm (1/16 – 1/8 in)) as designated in Reference Item No. 10, Annex A, with maximum isolated spot not exceeding 9.5 mm (3/8 in). There shall not be any visual evidence of pitting of the substrate and only the beginning of a buildup of red rust beneath the coating uplifted from the scribe.

6.2.4.5.3 For twin enclosed carbon-arc, the specimens shall be exposed for 360 h to light and water in accordance with Reference Item No. 11, Annex A, using the apparatus designated as type DH. Method 1, continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of 120 min consisting of a 102-min light exposure and an 18-min exposure to water spray with light, shall be used. The apparatus shall operate with a black-panel temperature of 63 ±3°C (145 ±5°F).

6.2.4.5.4 For xenon-arc, the specimens shall be exposed for 500 h to light and water in accordance with Reference Item No. 12, Annex A, using the apparatus designated as type BH. Test Method A, continuous exposure to light and intermittent exposure to water spray, with a programmed cycle of 120 min consisting of a 102-min light exposure and an 18-min exposure to water spray with light, shall be used. The apparatus shall operate with a 6500 W, water-cooled xenon-arc lamp, borosilicate glass inner and outer optical filters, a spectral irradiance of 0.35 W/m^2/nm at 340 nm, and a black-panel temperature of 63 ±3°C (145 ±5°F).

6.2.4.6 Resistance to salt spray (fog)

6.2.4.6.1 Six as-received and six air-oven conditioned specimens shall be exposed to the salt spray (fog) for 600 h in accordance with Reference Item No. 13, Annex A. Three of the as-received and three of the air-oven conditioned specimens shall be scribed as described in Clause 6.2.4.3.2.

6.2.4.6.2 As a result of the conditioning, the unscribed specimens shall not show more than a light corrosion beneath the coating system, with no visible pitting of the substrate and only the beginning of a buildup or weeping of red rust. For the scribed specimens, the average creeping distance of red rust from the scribe shall not be greater than Rating No. 5 (3.2 – 4.8 mm (1/8 – 3/16 in)) as designated in Reference Item No. 14, Annex A, with maximum isolated spot not exceeding 9.5 mm (3/8 in). There shall not be any separation of the coating from the substrate as a result of the exposure.

6.2.4.7 Resistance to moist carbon dioxide-sulfur dioxide-air

6.2.4.7.1 Six as-received and six air-oven conditioned specimens shall be exposed to the moist carbon dioxide-sulfur dioxide-air for 1200 h. The apparatus used for this exposure shall consist of a chamber having a volume of at least 0.085 m^3 (3 ft^3) with a water jacket and thermostatically controlled heater to maintain a temperature of 35 ±2°C (95 ±3°F). Three of the as-received and three of the air-oven conditioned specimens shall be scribed as described in Clause 6.2.4.3.2.

6.2.4.7.2 As a result of the conditioning, the unscribed specimens shall not show more than a light corrosion beneath the coating system, with no visible pitting of the substrate and only the beginning of a buildup or weeping of red rust. For the scribed specimens, the average creeping distance of red rust from the scribe shall not be greater than Rating No. 6 (1.6 – 3.2 mm (1/16 – 1/8 in)) as designated in Reference Item No. 15, Annex A, with maximum isolated spot not exceeding 9.5 mm (3/8 in). There shall not be any separation of the coating from the substrate as a result of the exposure.

6.2.4.7.3 The carbon dioxide and sulfur dioxide shall be supplied to the test chamber from commercial cylinders containing the gases under pressure. An amount of carbon dioxide equivalent to 1 percent of the volume of the test chamber and an equal volume of sulfur dioxide shall be introduced into the chamber each working day. Prior to introducing the new charge of gas each day, the remaining gas-air mixture from the previous day shall be purged from the chamber. A small amount of water shall be maintained at the bottom of the chamber for humidity. This water shall not be changed during the exposure. The specimens shall be supported in plastic racks at an angle of 15 degrees from the vertical.