# UL 224

## STANDARD FOR SAFETY

Extruded Insulating Tubing

UL Standard for Safety for Extruded Insulating Tubing, UL 224

Seventh Edition, Dated May 5, 2021

***Summary of Topics***

***This New Seventh Edition of ANSI/UL 224 includes updates to referenced publications.***

The requirements are substantially in accordance with Proposal(s) on this subject dated September 20, 2020 and October 16, 2020.

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CSA Group
CSA C22.2 No. 198.1:21
Fourth Edition

Underwriters Laboratories Inc.
UL 224
Seventh Edition

# Extruded Insulating Tubing

May 5, 2021



Approved American National Standard

ANSI/UL 224-2021

**Commitment for Amendments**

This standard is issued jointly by 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 CSA Group or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of 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.

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This ANSI/UL Standard for Safety consists of the Seventh edition.

The most recent designation of ANSI/UL 224 as an American National Standard (ANSI) occurred on May 5, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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# Preface

This is the harmonized CSA Group and UL standard for Extruded Insulating Tubing. It is the fourth edition of CSA C22.2 No. 198.1 and the seventh edition of UL 224. This edition of CSA C22.2 No. 198.1 supersedes the previous edition(s) published on March 6, 2006. This edition of UL 224 supersedes the previous edition published on March 6, 2006.

This harmonized standard was prepared by the CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee 15C, Electrical Tubing and Sleeving Products, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

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



### Application of Standard

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

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

### Level of Harmonization

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

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

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

### Reasons for Differences From IEC

The Technical Harmonization Subcommittee identified the following standard as being within the scope of this standard: IEC 60684, Flexible Insulating Sleeving. IEC 60684 and CSA C22.2 No. 198.1/UL 224 are similar but not identical. Both standards cover multiple, but not identical, products and similar methods. The THC agreed to address the issues involved in the harmonization of these standards during the next revision of CSA C22.2 No. 198.1/UL 224.

**Interpretations**

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

# Extruded Insulating Tubing

## 1 Scope

1.1 This Standard specifies the requirements for insulating tubing that is usually round in cross-section and that consists entirely of extruded compounds whose characteristic constituents are thermosetting, elastomeric, or thermoplastic polymers (see Table 1 for materials and ratings). These requirements also cover heat-shrinkable and crosslinked tubing.

1.2 Tubing is intended for use only in air – in dry and damp locations – as part of the internal wiring of electrical devices and appliances in accordance with the Canadian Electrical Code, Part 1 (CE Code, Part 1) and ANSI/NFPA 70, National Electrical Code (NEC). It may be used for insulating one or more inadequately insulated conductors, bus bars, motor leads, transformer leads, terminal lugs, or small assemblies of electronic components. Tubing is not intended for use in contact with sharp edges, corners, or projections, or where subject to tension, compression, or repeated flexing. Tubing is not intended for use where it is feasible to employ a standard insulated conductor (appliance wiring material) intended specifically for the purpose.

1.3 These requirements do not apply to fabric tubing, chemically dilated tubing, polymeric tubing extruded with reinforcement, or tubing intended only for mechanical protection.

1.4 The acceptability of tubing in any particular device or appliance depends upon its acceptability for continued use under the conditions that prevail in actual service. Accordingly, for a particular application, it will in some cases be necessary to employ tubing having features other than or in addition to those specified in these requirements. For example, tubing may be required to have a heavier wall thickness or a flat rather than a round cross-section; it may be required to have inherent resistance to the effects of immersion in water, oil, solvents, or other liquids (or their vapors); it may be required to be used in an environment conducive to the development of fungi and similar organisms.

## 2 Reference Publications and Definitions

### 2.1 Reference publications

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.

**CSA Group**

C22.1 No. 1:21
*Canadian Electrical Code, Part I*

CAN/CSA C22.2 No. 0.17-00 (R2018)
*Evaluation of Properties of Polymeric Materials*

C22.2 No. 2556:21
*Wire and cable test methods*

**UL (Underwriters Laboratories Inc.)**

UL 746B
*Standard for Polymeric Materials – Long Term Property Evaluations*

UL 2556
*Wire and cable test methods*

**ANSI/NFPA (American National Standards Institute/National Fire Protection Association)**

NFPA-70-2002
*National Electrical Code*

**ASTM (American Society for Testing and Materials)**

ASTM D257-14
*Standard Test Methods for DC Resistance or Conductance of Insulating Materials*

ASTM D412-98a (2002)e1
*Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers – Tension*

ASTM D471-16a
*Standard Test Method for Rubber Property – Effect of Liquids*

ASTM D876-13
*Standard Test Methods for Nonrigid Vinyl Chloride Polymer Tubing Used for Electrical Insulation*

ASTM D2671-13
*Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use*

ASTM D5025-12e1
*Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*

ASTM D5207-14
*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 D5374-13
*Standard Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation*

ASTM D5423-14
*Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation*



## 2.2 Definitions

2.2.1 The following definitions apply in this Standard:

2.2.2 **Chlorinated polyolefin** – a polymer or polymer blend based on chlorinated polyolefin (s) or chlorinated polybutadiene polymer(s).

2.2.3 **Heat-shrinkable tubing** – tubing that, upon the controlled application of heat, will reduce in diameter to a specified maximum recovered diameter.

2.2.4 **Polyolefin** – a polymer made by the polymerization of hydrocarbon olefins or copolymerization of hydrocarbon olefins with other non-halogenated monomers such as vinyl acetate or ethyl acrylate.

2.2.5 **Sample** – a quantity of material or finished product considered representative of a lot taken for the purpose of preparing specimens for test evaluation.

2.2.6 **Secant modulus** – 50 times the tensile stress at 2 percent elongation, expressed in MPa (psi).

2.2.7 **Specimen** – the actual unit of material or finished product upon which test evaluations are performed.

2.2.8 **Tubing with meltable liner** – tubing constructed of either

a) an outer wall that is crosslinked and a thermoplastic inner wall that flows and provides a seal when the tubing is recovered by heat; or

b) an outer wall with an adhesive or sealant inner wall applied to the inside, such that the inner wall flows and provides a seal when the tubing is recovered by heat.

## 3 General

### 3.1 Item references

Wherever Item numbers appear in a capability test description, the appropriate table of requirements for the specific type of tubing under investigation shall be selected.

### 3.2 Units of measurement

The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only, except for conductor sizes where the equivalent metric values are in parentheses.

## 4 Construction

### 4.1 Materials and quality of work

Tubing shall be made and finished with the degree of uniformity and quality of work that are practicable in a well-equipped factory. Only compounds qualified as acceptable for the manufacture of tubing complying with the requirements of this Standard shall be used.

### 4.2 Color

4.2.1 If the tubing is to be considered in a range of colors, specimens representing the full color range shall be provided for evaluation. Samples in the clear and most heavily pigmented black and white colors shall be provided and be considered representative of the color range, if the performance characteristics are essentially the same. If the performance characteristics are not essentially the same for all specimens representing the range, acceptance shall be limited to the tubing only in the colors tested, unless additional specimens in intermediate colors are provided for tests. (See 5.3.2.)

4.2.2 Notwithstanding 4.2.1, if the same base compound is employed for all colors of tubing, then only the clear and black samples shall be required for testing.

### 4.3 Minimum wall thickness

4.3.1 The wall thickness of the tubing (fully recovered in the case of heat-shrinkable tubing) shall not be less than the values specified in the respective tables in this Standard with a tolerance of +20 / - 0 %. The values in the respective tables will then be considered the minimum production wall thickness.

Note: If the measured values exceed the 20 % tolerance, the measured values will be used as the minimum production wall thickness values.

4.3.2 For single-wall tubing, the minimum thickness shall be determined by means of a dead-weight pin gauge micrometer having a resolution of at least 0.01 mm (0.0004 in) with a presser foot 1.09 mm (0.043 in) wide and 7.92 mm (0.312 in) long and a pin that is 1.09 mm (0.043 in) in diameter and 11.10 mm (0.437 in) long. The presser foot shall exert 0.25 ±0.02 N (0.056 ±0.0045 lbf) on the specimen. The specimen shall be hung on the pin carefully so that the entire length of the presser foot makes contact with the specimen. The presser foot shall be brought to rest gently on the specimen and the reading shall be taken immediately. It is necessary to rotate the specimen and to make several measurements to determine the actual minimum thickness. In no case shall the presser foot be in contact with the specimen while the specimen is being rotated. As a referee or secondary method, a calibrated micrometer microscope that can be read to the nearest 0.001 mm (0.0001 in) shall be used.

4.3.3 For tubing with a meltable liner, the thickness of the inner wall shall not be included when determining the wall thickness. If the inner wall is removable by physical or chemical means, the manufacturer shall provide instructions for its removal. If the inner wall is not removable, measurements of the outer wall shall be made using a calibrated micrometer microscope that can be read to the nearest 0.001 mm (0.0001 in).

### 4.4 Heat-shrinkable tubing

Heat-shrinkable tubing shall reduce in diameter and conform to the minimum wall thickness requirements specified in Table 34 and Table 36, as applicable, upon the controlled application of heat. For tubing with a meltable liner, the thickness of the inner wall shall not be included.

## 5 Capability tests

### 5.1 Pre-conditioning and test conditions

5.1.1 Unless otherwise specified all testing, except flammability, should be conducted at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10 %. Flammability testing shall be conducted in still air at a temperature of 15 – 35 °C (59 – 95 °F) and a relative humidity of < 75 %. All samples shall be preconditioned at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10 % for a minimum of 30 minutes prior to test.

### 5.2 Circulating air-oven

The apparatus for the air-oven aging of specimens shall be in accordance with ASTM D 5423 Type II. The motor-operated fan or other means for circulating the air shall be located entirely outside the aging chamber. The oven shall maintain the specified temperature within ±1.0 °C (±1.8 °F).

### 5.3 Samples

5.3.1 A complete set of samples or specimens shall be provided as scheduled in Table 2 and Table 3.

5.3.2 If the tubing is to be evaluated in a range of colors, the required test samples shown in Table 2 shall be provided as specified in 4.2.

5.3.3 If different compounds are employed, samples produced from the alternative compounds shall be provided for tests. (See 4.1.)

5.3.4 The inner and outer surfaces of tubing (excluding the meltable liner) shall be smooth and free from blisters, cracks, and other defects that can be detrimental to the tubing in its intended use. Tubing shall not peel, scale, or flake.

5.3.5 Except where specified otherwise, heat-shrinkable tubing shall be examined and tested in the fully recovered condition, which shall be achieved in accordance with the manufacturer's instructions.

5.3.6 The minimum expanded inside diameter and the maximum recovered inside diameter of heat shrinkable tubing referred to in the capability tests of 5.4 to 5.20 shall be the values specified for the product by the manufacturer.

### 5.4 Physical properties

#### 5.4.1 General

5.4.1.1 The tensile strength and ultimate elongation of the tubing shall not be less than the values tabulated in Items 6 and 7 of Table 7 to Table 32, as applicable, for unaged specimens and in Items 11 and 12 of Table 7 to Table 32, as applicable, for aged specimens. Oil-resistant tubing shall comply with the requirements in 5.5.

5.4.1.2 For the preparation, aging, and testing of specimens of tubing, the equipment mentioned in 5.4.2 to 5.4.6 shall be used.

#### 5.4.2 Specimen conditioning

Physical tests shall be made on both unaged and aged specimens at the same time. Unaged specimens shall be maintained at the temperature and humidity specified in 5.1.1 for not less than 30 minutes prior to being subjected to the physical tests. Specimens that have been subjected to air-oven aging shall rest for not less than 16 hours and not more than 96 hours at the temperature and humidity specified in 5.1.1 following their removal from the oven and prior to their being subjected to the physical tests. Specimens that have been subjected to oil immersion shall be blotted lightly to remove any excess oil and conditioned at the temperature and humidity in 5.1.1 for 3.5 to 4.5 hours before being subjected to the physical tests. Specimens having widely different properties or composition shall be aged in separate ovens.

#### 5.4.3 Die for cutting specimens

5.4.3.1 The die for cutting specimens from lengths of finished flexible tubing shall be die C described in ASTM D412. (See Figure 1.)

5.4.3.2 The die for cutting specimens from lengths of finished semi-rigid or rigid tubing shall be die D described in ASTM D412. (See Figure 2.)

5.4.3.3 The use of a press for operating the die is recommended. The cutting shall be done on a smooth surface of material that cannot damage the cutting edges of the die.

#### 5.4.4 Specimen marker

The specimen marker shall consist of a stamp with parallel metal blades capable of making fine inked lines (benchmarks) on a specimen. The lines shall be 25 mm (1 in) apart and shall be applied at right angles to

the longitudinal axis of the specimen. The ink shall be of any color that contrasts with that of the specimen, and of a composition that does not in any way damage the specimen.

### 5.4.5 Apparatus for aging

#### 5.4.5.1 General

The apparatus for the aging of specimens specified in these requirements shall include the equipment mentioned in 5.2 and 5.4.5.2. In each type of apparatus, provision shall be made for suspending the specimens vertically within the chamber without touching the sides of the chamber or any other specimens.

#### 5.4.5.2 Oil-immersion aging

5.4.5.2.1 The immersion vessel for tubular specimens shall be a test tube having an overall diameter of at least 25 mm (1 in) and a length that facilitates immersion of a straight specimen at least 152 mm (6 in) long. The tube shall be filled with the oil specified in 5.4.5.2.2 and then placed in a bath having an automatic temperature control that maintains the specimens at the specified temperature. Tubing shall be filled with the maximum diameter of solid copper conductor that fits tightly inside the tubing without damaging the tubing wall. For tubing smaller than 8.38 mm (0.330 in) inside diameter, specimens shall be bent at the center to form a narrow U and shall then be suspended vertically in the oil with the ends of each specimen projecting above the oil. After immersion for the specified length of time indicated in 5.5.4 to 5.5.6, each specimen shall be cut in half at the center of the U-bend to provide two specimens for physical tests. For tubing larger than 8.38 mm (0.330 in) inside diameter, die-cut specimens shall be suspended vertically in the oil.

5.4.5.2.2 The oil to be used shall be IRM 902 oil as described in ASTM D471. Measured at 98.9 °C (210.0 °F), the Saybolt Universal Viscosity of IRM 902 oil is 101.9 ±5 seconds. It has an aniline point of 92.8 ±3.0 °C (199.0 ±5.4 °F) and an open-cup flash point of 243.3 ±5.6 °C (470.0 ±10 °F).

### 5.4.6 Tensile testing machine

Measurements for the tensile strength and ultimate elongation determinations shall be made on a power-driven machine provided with a device that indicates the maximum load applied to the specimen. If a machine of the spring-balance type is used, provision shall be made to prevent recoil of the spring. The machine shall be adjusted to provide the rate of jaw separation tabulated for each class of tubing. The indication of the applied tension as read from a dial or scale shall be accurate to within 2 percent or less of the tension actually applied to the test specimen. A set of standard weights shall be used for calibrating the machine, a method for which is included in ASTM D412.

### 5.4.7 Specimen preparation

5.4.7.1 Specimens for the tensile strength and ultimate elongation measurements shall be selected from unaged and aged samples of finished tubing. Specimens intended for aging shall be cut before being positioned in the air oven.

5.4.7.2 For tubing smaller than 8.38 mm (0.330 in) inside diameter, fully recovered in the case of heat-shrinkable tubing, test specimens shall be prepared by cutting the sample tubing into lengths and subjecting each length to test in tubular form. As an alternative for tubing with meltable liner, samples shall be slit longitudinally in half prior to aging as long as the adhesive remains in contact with the inner surface of the tubing during conditioning. For 8.38 mm (0.330 in) inside diameter and larger tubing, die-cut specimens shall be prepared. This shall be done by cutting one wall of the tubing parallel to the longitudinal axis of the tubing, flattening the piece, and applying the die parallel to the axis on which the cut