



UL 83A

STANDARD FOR SAFETY

Flouropolymer Insulated Wire

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UL Standard for Safety for Fluoropolymer Insulated Wire, UL 83A

First Edition, Dated February 1, 2016

Summary of Topics

This is the First Edition of ANSI/UL 83A.

The new requirements are substantially in accordance with Proposal(s) on this subject dated November 20, 2015.

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FEBRUARY 1, 2016

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ANSI/UL 83A-2016

UL 83A

Standard for Fluoropolymer Insulated Wire

First Edition

February 1, 2016

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 83A as an American National Standard (ANSI) occurred on February 1, 2016. ANSI approval for a standard does not include the Cover Page, Transmittal Pages and Title Page.

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>.

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APPENDIX C (Informative) Evaluation of Materials Having Characteristics Differing from Those in Table 12

1 Scope

1.1 This Standard specifies the requirements for 600 V, single-conductor, fluoreopolymer-insulated wires and cables in accordance with NFPA 70, National Electrical Code (NEC).

Note: See Appendix A for the complete list of wire types covered by this Standard.

1.2 Products for which this Standard provides requirements might have applications not described in the electrical code listed in 1.1.

2 General

2.1 Units of measure

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Reference publications

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

UL Standards

UL 1685

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

UL 2556

Wire and Cable Test Methods

ASTM (American Society for Testing and Materials) Standards

B3-13,

Standard Specification for Soft or Annealed Copper Wire

B8-11,

Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B33-10(2014),

Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

B160-10(2014),

Standard Specification for Nickel Rod and Bar

B172-10(2015),

Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B173-10(2015),

Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

B174-10(2015),
Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors

B355-11,
Standard Specification for Nickel-Coated Soft or Annealed Copper Wire

IEC (International Electrotechnical Commission) Standards

60228 (2004-11),
Conductors of insulated cables

NFPA (National Fire Protection Association) Publication

NFPA 70,
National Electrical Code (NEC)

2.3 Summary of requirements

2.3.1 As a guide to users of this Standard, a summary of requirements is provided in Appendix A.

3 Definitions

3.1 The following definitions apply in this Standard:

3.2 EQUIPMENT-GROUNDING CONDUCTOR – a conductor that is defined in the NEC, as "Grounding Conductor, Equipment".

3.3 ETFE – Ethylene tetrafluoroethylene

3.4 FEP – Fluorinated ethylene propylene

3.5 PFA – Perfluoroalkoxy

3.6 TFE – Polytetrafluoroethylene

3.7 THERMOPLASTIC – a polymeric material that can repeatedly be softened by heating and hardened by cooling and that in the softened state can be shaped through the application of force.

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4 Construction

4.1 Conductors

4.1.1 General

4.1.1.1 Circuit and equipment-grounding conductors shall be of copper or of a nickel-based alloy.

4.1.2 Copper conductors

4.1.2.1 General

4.1.2.1.1 The requirements of 4.1.2.2 or 4.1.2.3 shall apply to solid conductors or the individual wires of stranded conductors prior to stranding.

4.1.2.2 Bare copper conductors

4.1.2.2.1 Each wire in a bare copper conductor shall comply with the requirements of ASTM B3.

4.1.2.3 Tin-coated copper conductors

4.1.2.3.1 Each wire in a tin-coated conductor shall comply with the requirements of ASTM B33. Overcoating of 2.08 mm² (14 AWG), 3.31 mm² (12 AWG), and 5.26 mm² (10 AWG) stranded copper conductor with a layer of tin shall be optional.

4.1.2.4 Nickel-base alloy conductors

4.1.2.4.1 Each wire in a nickel-base alloy conductor shall comply with the requirements of ASTM B160.

4.1.2.5 Nickel-coated copper conductors

4.1.2.5.1 Each solid copper conductor and each strand in a stranded copper conductor shall be protected against oxidation by a coating of nickel complying with ASTM B355

4.1.3 Sizes and stranding

4.1.3.1 Sizes

4.1.3.1.1 Conductors shall be as shown in Table 1.

Note: IEC conductor sizes are not recognized in the NEC, however, these sizes can be required for wires and cables intended for use outside of the codes. As a guide to users of this Standard, information on IEC conductors is provided in Appendix B.

4.1.3.2 Stranding

4.1.3.2.1 General

4.1.3.2.1.1 The minimum number of wires (strands) in a conductor shall be in accordance with Table 2.

4.1.3.2.1.2 Copper strands smaller than 0.0127 mm^2 (36 AWG) shall not be used.

4.1.3.2.2 Compressed

4.1.3.2.2.1 A compressed-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more layers of helically laid wires with either the direction of lay reversed in successive layers or unilay or unidirectional lay. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers shall be slightly compressed by rolling, drawing, or other means to change the originally round strands to various shapes that achieve filling of some of the spaces originally present between the strands.

4.1.3.2.3 Assembly of strands

4.1.3.2.3.1 A 19-wire combination round-wire unilay stranded conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire, and an outer layer consisting of six wires with the same diameter as the central wire alternated with six wires with a diameter of 0.732 times the diameter of the central wire. No particular assembly of the individual wires of any other stranded conductor shall be required. However, simple bunching (untwisted strands) shall not be used. The length of lay of the strands in a bunch-stranded conductor twisted as a single bunch shall not be greater than as indicated in Table 3. The direction of lay of the strands in a bunch-stranded conductor shall be left-hand.

4.1.3.2.4 Length and direction of lay

4.1.3.2.4.1 Every stranded conductor other than a bunch-stranded conductor twisted as a single bunch shall comply with the following:

a) The direction of lay of the strands, members, or ropes in a $13.3 - 107 \text{ mm}^2$ (6 AWG – 4/0) conductor, other than a combination unilay or a compressed unilay or compressed unidirectional lay conductor, shall be reversed in successive layers. Rope-lay conductors with bunch-stranded or concentric-stranded members shall be either unidirectional or reversed. All unidirectional lays and the outer layer of reversed lays shall be in the left-hand direction.

b) For a bunch-stranded member of a rope-lay-stranded conductor in which the members are formed into rope-stranded components that are then cabled into the final conductor, the length of lay of the individual members within each component shall not be more than 30 times the outside diameter of one of those members.

c) For a concentric-stranded member of a rope-lay-stranded conductor, the length of lay of the individual strands in a member shall be 8 – 16 times the outside diameter of the member. The direction of lay of the strands in each member shall be reversed in successive layers of the member.

- d) The length of lay of the strands in both layers of a 19-wire combination round-wire unilay-stranded copper conductor shall be 8 – 16 times the outside diameter of the completed conductor. Otherwise, the length of lay of the strands in every layer of a concentric-lay-stranded conductor consisting of fewer than 37 strands shall be 8 – 16 times the outside diameter of the conductor.
- e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of the conductor.
- f) The length of lay of the members or ropes in the outer layer of a rope-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer.

4.1.4 Diameter and cross-sectional area

4.1.4.1 The nominal diameters of solid and stranded conductors are shown in Tables 4 – 7. The minimum diameter for stranded conductors is 98 percent of the nominal. The maximum diameter is 101 percent of the nominal. The diameter shall be determined in accordance with the test, Conductor diameter, in UL 2556.

4.1.4.2 Conductor sizes in mm² (AWG/kcmil) covered by this Standard are shown in Table 4. The nominal cross-sectional area of a conductor identified in Table 4 is not a requirement.

4.1.4.3 The nominal cross-sectional area, if required, shall be determined in accordance with the test, Cross-sectional area, in UL 2556.

4.1.4.4 Compressed unilay or compressed unidirectional lay copper conductors that are smaller in diameter than the requirement (0.98 x nominal in Table 5) for compressed concentric lay conductors shall be marked in accordance with 6.1.6.

4.1.5 Joints

4.1.5.1 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall neither increase the diameter nor materially decrease the strength of the conductor or the individual wire. Not more than one of the wires in a stranded conductor of 19 wires or less, nor more than one of the wires in any given layer in a stranded conductor of more than 19 wires, shall be joined in any 0.3 m (1 ft) of conductor.

4.1.5.2 In a rope-lay-stranded conductor, which consists of a central core surrounded by one or more layers of stranded members (primary groups), each member shall be considered equivalent to a solid wire, and as such, shall be spliced as a unit. These joints shall not be any closer together than 2 lay lengths.

4.1.5.3 A joint shall be allowed in a Class B stranded 2.08 mm² (14 AWG), 3.31 mm² (12 AWG), or 5.26 mm² (10 AWG) insulated copper conductor intended to be used in a multiple-conductor cable, with an overall covering. The joint (butt splice) shall be made by machine brazing or welding the entire conductor such that the resulting solid section of the stranded conductor is no longer than 13 mm (0.50 inch). In addition, the joint shall not increase the diameter of the conductor, there shall be no sharp points, and the distance between joints in a single conductor shall not average less than 1000 m (3280 ft) in any finished length of that single insulated conductor. A joint (butt splice) shall be made before or after insulating and prior to further processing. Where joints (butt splices) are made after insulating, the insulation applied over the joint shall be of the same insulation material used throughout the length of the conductor, or of another insulating material that meets or exceeds the electrical, physical, and mechanical requirements of this

Standard for the original insulating material. Joints in bare or insulated equipment-grounding conductors shall not be allowed. Insulated conductors with a joint (butt splice) shall not be surface marked with a type designation.

4.1.6 Separator

4.1.6.1 A separator of suitable material between the conductor and the insulation shall be optional. The separator shall be of contrasting color to the conductor color, except that clear or green shall not be used. The separator and the other wire or cable components shall not have any deleterious effect on each other.

4.2 Insulation

4.2.1 General

4.2.1.1 Conductors shall be insulated for their entire length with thermoplastic material meeting all the requirements of this Standard. The insulation shall be applied directly over the conductor, or over the separator if provided, and shall fit tightly thereto. The insulation shall be free from pores, splinters, and other inhomogeneities visible without magnification to normal or corrected-to-normal vision.

4.2.1.2 If the insulation is applied in more than one layer, the interface between the layers shall be free of voids visible without magnification to normal or corrected-to-normal vision, and all layers shall be taken together for all measurements and tests.

4.2.2 Repairs

4.2.2.1 Where a repair is made in the insulation, the insulation applied to the repaired section shall be equivalent to that removed, and the repaired section of the finished conductor shall comply with the same electrical and thickness requirements specified in this Standard.

4.2.3 Colored insulation

4.2.3.1 When colored insulation is required, either the insulation shall be colored throughout its thickness or a thin colored coating of suitable material shall be applied to the surface of the insulation. The coating material shall not have an adverse effect on the properties of the insulation. If the coating is of an extruded type, it shall be considered as part of the insulation and shall comply with all requirements.

4.2.3.2 Polarity identification of circuit conductors other than the grounding or grounded conductor shall be provided by means of contrasting colors other than white, gray, or green; by ridges; by stripes; or by word printing. Grounded circuit conductors shall be colored white or gray or shall have three continuous white stripes on a background of other than green or green with yellow stripes. Longitudinal white stripes shall be spaced nominally 120 degrees apart. The equipment-grounding conductor shall be colored green or green with continuous or broken yellow stripes.

4.2.3.3 Stripes as specified in 4.2.3.2 shall be of even or varying width and shall occupy a total of 5 – 70 percent of the calculated circumference of the outer surface of the finished insulated conductor with no individual width less than 5 percent of that same circumference. The width shall be measured perpendicular to each stripe. Where broken stripes are appropriate, they shall consist of a series of identical marks and spaces, the length of each mark shall be at least 3 mm (1/8 inch), and the linear spacing between marks shall not be greater than 19 mm (3/4 inch).

4.2.4 Thickness and centering

4.2.4.1 The average and minimum thickness of the insulation shall be as shown in Tables 9 – 12. Compliance shall be determined in accordance with the test, Thickness, in UL 2556.

4.2.4.2 The insulation shall have a circular cross-section, with the insulation applied concentrically about the conductor and fitting tightly on the conductor or over any separator.

4.2.5 Physical properties of insulation

4.2.5.1 General

4.2.5.1.1 The tensile strength and ultimate elongation of the insulation, before and after aging, shall be as specified in Table 13.

4.2.5.2 Test requirement

4.2.5.2.1 Compliance with 4.2.5.1.1 shall be determined in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556.

4.2.5.3 Evaluation of alternative insulation materials for use in this Standard (see Appendix C)

4.2.5.3.1 Alternative insulation materials for products shall be evaluated in accordance with the test, Dry temperature rating of new materials (long-term aging test), in UL 2556.

4.2.5.3.2 Materials having characteristics different from those specified in Table 13 shall be evaluated for the requested temperature rating in accordance with 5.15. To be evaluated, materials shall have an initial absolute minimum tensile strength of not less than 6.8 MPa (1000 lbf/in²), and an absolute minimum elongation of 100 percent before aging.

4.2.5.3.3 The temperature rating and thickness of those materials having characteristics different from those specified in Table 13 shall be as required for the specific thermoplastic-insulated wire or cable type. The electrical, mechanical, and physical characteristics of the wire or cable using these materials shall be such that the materials meet the specified requirements for the temperature rating.

4.2.5.3.4 Insulation material complying with 4.2.5.3.2 shall then be evaluated to establish requirements for its specific physical properties in Table 14.

4.3 Assemblies that include thermoplastic-insulated single conductors

4.3.1 When cabled into assemblies (length and direction of lay not specified), single-conductor wires that comply with the requirements in this Standard shall not be considered cables, and do not include overall coverings. An open, skeleton tape or wrap intended only to hold the assembly together shall be allowed. Such assemblies shall be allowed to include other single-conductor wires or cables not covered in this Standard. An assembly may contain a bare copper conductor – size is not specified – that is coated with tin or other metal shall be optional. A bare, coated copper conductor shall not be covered. The completed assembly shall meet the following requirements:

- a) Assemblies in which a bare, coated copper conductor is included shall be tested for dielectric voltage-withstand as indicated in 5.17, except that immersion in water shall be for at least 1 hour.
- b) Each assembly in which a bare conductor is not included shall either be tested as indicated in 5.17 (1 hour or longer immersion) or be spark tested as indicated in 5.16, with each layer in a multiple-layer assembly sparked separately.
- c) Each 2.08 – 8.37 mm² (14 AWG – 8 AWG) conductor in an assembly shall be individually tested for continuity after the assembly is completed.

4.4 Braids

4.4.1 Type FEPB wire in size 14 – 2 AWG shall be provided with a lacquer-coated glass braid applied over the insulation. The lacquer coating on the glass braid on size 14 – 2 AWG Type FEPB wires shall not reduce the ability of the finished wires to comply with the applicable flame test(s) in this Standard.

5 Test requirements

5.1 General

5.1.1 Every length of finished insulated conductor shall be capable of meeting the test requirements set out in 5.2 – 5.19, as applicable.

5.2 Conductor resistance

5.2.1 The direct-current resistance of the conductor shall not be greater than shown in Tables 15 – 23 inclusive. For conductors for which the maximum resistance is not tabulated in Tables 15 – 23, the maximum resistance for a given size of the solid or stranded construction shall be determined by multiplying the maximum resistance tabulated in the tables for uncoated copper of the same size and construction by the ratio of 100 percent IACS (International Annealed Copper Standard) to the percent conductivity as shown in the applicable conductor standard.

5.2.2 A twisted conductor assembly shall not exceed the value tabulated in Tables 15 – 23 as applicable, for a single conductor multiplied by whichever of the following factors is applicable:

- a) Cabled in one layer: 1.02;
- b) Cabled in more than one layer: 1.03; or
- c) Cabled as an assembly of other pre-cabled units: 1.04.