

Subject 493

August 24, 2018

SUMMARY OF TOPICS

The following changes in requirements to the Standard for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables, UL 493, are being proposed:

1. Proposed Reorganization and New Tenth Edition of UL 493

STP BALLOTS AND ALL COMMENTS DUE: OCTOBER 23, 2018

1. Proposed Reorganization and New Tenth Edition of UL 493

RATIONALE

Proposal submitted by: Khaled Masri, NEMA.

The reorganization of UL 493 is proposed by NEMA to make the standard more user friendly and easier to follow. The proposed standard will follow the structure of the trinational building wire standards, UL 44 and UL 83, which were developed within CANENA. The proposed reformatting was developed with the assistance of the UL LLC principal engineering staff. The existing requirements of UL 493 are accounted for in the new format. Additionally, proposed changes as new Clause 3, 4.3.3, and 5.13 are included.

For the benefit of STP members not involved in this effort, a Word file showing old versus new clause numbering is available under "Supporting Documentation" on the Quick View tab, which appears on the right-hand side of the UL 493 Work Area in CSDS. This file serves to verify that all of the existing requirements are accounted for in the new format.

PROPOSAL

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1 Scope

1.1 These requirements cover 14 – 4/0 AWG single-conductor PVC-insulated and -jacketed underground feeder and branch-circuit cable and flat multiple-conductor PVC-jacketed underground feeder and branch-circuit cables containing two or three 14 – 6 AWG PVC-insulated circuit conductors with or without an equipment grounding conductor. These Type UF cables are intended for use in accordance with Article 340 and other applicable parts of the National Electrical Code, ANSI/NFPA 70 in wiring systems operating at a potential of 600 V or less. Submersible water-pump cables and multiple-conductor assemblies to which a type-letter designation is not assigned are also covered in these requirements.

1.2 Multiple-conductor cable that is marked "UF-B" has a 75°C jacket and conductors with insulation of 90°C dry and at least 60°C wet locations. Multiple-conductor cable that is marked "UF" has a 60°C jacket and conductors with insulation for 60°C dry and wet locations. Single-conductor cable is marked "UF" and has an integral insulation and jacket for 60°C dry and wet locations. The ampacity of all cables covered in these requirements is that of 60°C conductors.

1.3 These requirements do not cover insulation other than PVC, round cables containing two or more circuit conductors, flat cables containing more than three circuit conductors, or multiple-conductor cables containing circuit conductors larger than 6 AWG.

2 General

2.1 Units of measurement

2.1.1 In addition to being stated in the inch/pound units that are customary in the USA, each of the requirements in this standard is also stated in units that make the requirement conveniently usable in countries employing the metric system (practical SI). Equivalent – although not necessarily exactly identical – results are to be expected from applying a requirement in USA or metric terms. Equipment calibrated in metric units is to be used when a requirement is applied in metric terms.

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.

3 Definitions

3.1 The following definitions apply in this Standard:

Composite insulation system – a multiple-layer system of materials that fulfills the requirements for both electrical and mechanical integrity of the cable or wire.

Thermoplastic – a jacket or insulation material that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the material, and that in the softened state can be shaped through the application of force.

4 Construction

4.1 General

4.1.1 Underground feeder and branch-circuit cable shall be designated as Type UF and shall comply in all respects with the applicable requirements for construction details and test performance.

4.2 Materials

4.2.1 Only materials that are acceptable for the use shall be employed in a cable.

4.2.2 Each of the materials used for the insulation, spacers, fillers, jacket, and other non-metallic parts of a cable shall be resistant to fungi, moisture, and corrosion. In addition, each of the materials used as insulation on the circuit conductors shall be acceptable for use in wet locations.

4.2.3 Polypropylene, PVC, and glass are known to be resistant to fungi and hence are acceptable in this respect without exposure tests. Tests to determine the degree of resistance to fungi are to be made as indicated in the Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi, ASTM G21, on materials not known to have the requisite property. Cotton, paper, jute, hemp, and the like are not acceptable whether treated or not.

4.3 Conductors

4.3.1 Only soft-annealed copper, copper-clad aluminum, or an acceptable aluminum alloy shall be used for the conductor or conductors in a cable. Soft-annealed copper shall comply with the Standard Specification for Soft or Annealed Copper Wire ASTM B3. Solid aluminum conductors in size 12 – 8 AWG shall comply with the requirements for aluminum-wire stock (aluminum-alloy conductor material). All other aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in Section 10 of UL 1581. Copper-clad aluminum conductors shall comply with the requirements in Section 11 of UL 1581. In a given cable, all conductors shall be of the same metal.

4.3.2 The conductor in single-conductor cable shall not be smaller than 14 AWG and shall not be larger than 4/0 AWG if of copper, and shall not be smaller than 12 AWG and shall not be larger than 4/0 AWG if of aluminum or copper-clad aluminum. A copper circuit conductor in a multiple-conductor cable shall not be smaller than 14 AWG and shall not be larger than 6 AWG. An aluminum or copper-clad aluminum circuit conductor in a multiple-conductor cable shall not be smaller than 12 AWG and shall not be larger than 6 AWG.

4.3.3 Single conductors sized 14 – 8 AWG may be solid or stranded, and single conductors sized 6 – 4/0 AWG shall be stranded. In multiple-conductor cable constructions, 14 – 10 AWG conductors may be solid or stranded, and 8 – 4/0 AWG conductors shall be stranded. See 7.1.1 for single-conductor cables that comprise pump cables.

4.3.4 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall be made in a workmanlike manner and shall not increase the diameter of the solid conductor, the individual wire strand, or the overall stranded conductor. A joint shall not be made in a stranded conductor as a whole but shall be made by separately joining each individual wire. A joint shall be made only before coverings, if any, are applied to an insulated conductor. The insulation applied to such joints shall be equivalent to that removed and shall have insulation-resistance and dielectric withstand-voltage characteristics complying with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

4.3.5 Conductors shall comply with the requirements in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

4.4 Insulation and coverings

4.4.1 The circuit conductors in a finished multiple-conductor cable that is marked "UF-B" shall not have any surface marking of the ampacity or temperature rating and shall comply with one of the following:

- a) NYLON JACKET OVER INSULATION – The insulation and the nylon jacket shall comply with the thickness and other applicable requirements for Types THWN-2, THWN, and THHN thermoplastic-insulated wires. The markings "THWN-2", "THWN", "THHN", "THWN OR THHN", and "-B" shall not be used.
- b) NO NYLON JACKET – The insulation shall comply with the thickness requirements for a Type TW thermoplastic-insulated wire complying with the requirements for both Type TW and THHN insulation (tensile strength and elongation complying with Table 50.155 of UL 1581 and deformation test conducted at $121.0 \pm 1.0^{\circ}\text{C}$ with a decrease of not more than 50 percent in the thickness of the PVC insulation). The surface marking "-B" is optional on the insulation.

4.4.2 In all single- and multiple-conductor cables that are marked "UF" (without the suffix "-B"), the insulation employed on the circuit conductor or conductors shall comply with the applicable requirements for Type TW thermoplastic-insulated wire (the surface marking "TW" is optional on the insulation). In any cable, an equipment grounding conductor shall be bare or shall be fully insulated in compliance with 4.5 and with the thickness and other requirements stated in this Section for the circuit conductors.

4.4.3 The insulation and jacket on single-conductor cable shall be integral with one another. The average and minimum-at-any-point thicknesses of the thermoplastic insulation determined on specimens of finished cable shall not be less than indicated in Table 1. The method of preparing specimens, taking the measurements, and determining compliance shall be as specified in the Standard for Thermoplastic Insulated Wires and Cables, UL 83.

4.5 Alternative materials

4.5.1 An insulation or jacket that is of material generically different from PVC (new material), or that is of the PVC material specified in this Standard yet does not comply with the short-term tests for the PVC insulation in Specific Materials, Section 50 of UL 1581, or with the tests for the PVC jacket in Table 2, shall be of a material and in thicknesses and with the temperature rating required for the specific underground feeder and branch-circuit cable type. The material shall be evaluated for the requested temperature rating as described in the test, Dry temperature rating of new materials (long-term aging test) of UL 2556.

4.5.2 Investigation of the electrical, mechanical and physical characteristics of the cable using the material shall show the material to be comparable in performance to the PVC insulation or jacket material specified in this Standard. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock, insulation resistance and dielectric voltage-withstand.

4.6 Assembly of multiple-conductor cables

4.6.1 General

4.6.1.1 At least two, but not more than three circuit conductors shall be used in a multiple-conductor cable. In a given cable, all of the circuit conductors shall be of the same size.

4.6.1.2 An equipment grounding conductor in a multiple-conductor cable is acceptable, but not required. An equipment grounding conductor shall not be part of a single-conductor cable.

4.6.2 Cabling methods

4.6.2.1 In multiple-conductor cable, the circuit conductors shall be laid parallel.

4.6.2.2 The metal of the circuit conductors in finished multiple-conductor cable, with or without an equipment grounding conductor, shall be at least as far apart as indicated in Table 3. A spacer of applicable material is an acceptable means of maintaining the separation.

4.6.2.3 The insulated circuit conductor or conductors, any equipment grounding conductor, and any insulation on the equipment grounding conductor shall be readily separable from one another and from the rest of the finished cable without damage to the insulation, covering, or any other part of the cable.

4.6.3 Equipment grounding conductor

4.6.3.1 If an equipment grounding conductor is used in multiple-conductor cable, it shall be entirely in one location in the cable, that is, it shall not be divided into two or more parts located separately or distributed helically.

4.6.3.2 In multiple-conductor cable, the equipment grounding conductor shall be placed in the valley between two of the circuit conductors, but not directly between the circuit conductors. In all constructions in which a bare equipment grounding conductor is used, this conductor shall be kept from coming into contact with circuit-conductor insulation and from moving between the circuit conductors.

4.6.3.3 The color of an insulated equipment-grounding conductor shall be as described in 6.1.2.

4.6.3.4 An equipment grounding conductor shall not be smaller than indicated in Table 4 or Table 5.

4.6.3.5 Finished multiple-conductor cable shall be essentially void-free and shall have a smooth, even, firm exterior. Fillers may be integral with the jacket or may be separate.

4.7 Outer covering on multiple-conductor cables

4.7.1 Assembled multiple-conductor cable shall be enclosed completely by a PVC jacket.

4.7.2 The physical properties of specimens of PVC jackets prepared from finished multiple-conductor cables shall comply with the requirements in Table 2. See 4.5.1 for the long-term evaluation of a jacket material other than PVC or of a PVC that does not comply with the short-term tests specified in Table 2.

4.7.3 The average and minimum point thicknesses of the PVC jacket shall not be less than indicated in Table 6. The method of preparing specimens, taking the measurements, and determining compliance is not specified however, in the event of disagreement, the referee method specified in 4.7.4 – 4.7.6 is to be used.

4.7.4 The minimum average thickness and the minimum thickness at any point of the jacket on finished multiple-conductor cable are to be determined by means of a pin-gauge dial micrometer whose presser foot exerts 25 ± 2 gf (0.25 ± 0.02 N) on a specimen. The pin is to be 0.437 inches (11.10 mm) long and 0.043 inches (1.09 mm) in diameter, and the rectangular end of the presser foot that makes contact with a specimen is to be 0.043 inches (1.09 mm) wide and 0.312 inches (7.92 mm) long. Specimens 2 – 6 inches (50 – 150 mm) long are to be cut from the finished cable and the metal circuit and equipment grounding conductors are to be withdrawn (not the insulation). The ends of each specimen are then to be sliced off perpendicular to the longitudinal axis of the specimen. The conductor insulation and any separable fillers are then to be withdrawn leaving only the undeformed jacket.

4.7.5 For cable with separable fillers, a total of 16 measurements [each estimated to the nearest 0.1 mil (0.001 mm)] is to be made (see upper drawing in Figure 1) at both ends of each specimen. For cable having two circuit conductors and filler integral with the jacket, 10 measurements [each estimated to the nearest 0.1 mil (0.001 mm)] are to be made (see center drawing in Figure 1) at both ends of each specimen. For cable having three circuit conductors and fillers integral with the jacket, 12 measurements [each estimated to the nearest 0.1 mil (0.001 mm)] are to be made (see lower drawing in Figure 1) at both ends of each specimen. The specimen of the jacket is to be placed on the pin and so located on the pin that the entire length of the presser foot makes contact with it. The presser foot is to be brought to rest gently on the specimen, and the reading [estimated to the nearest 0.1 mil (0.001 mm)] is to be taken immediately. The presser foot is not to be in contact with the specimen while the latter is being rotated. The 16, 10, or 12 measurements at each end of each specimen are to be averaged, and the smallest of the two averages for each specimen is to be rounded off to the nearest 1 mil (0.01 mm) and is then to be compared with the average thickness specified in Table 6. When the average for a specimen is less than the average in the table, the cable is not acceptable.

4.7.6 The lowest single reading on either end of a specimen is to be rounded off to the nearest 1 mil (0.01 mm) and compared with the minimum thickness at any point specified in Table 6. In the case of an equipment grounding conductor in a cable with integral jacket and fillers, an additional measurement is to be made as shown as 11 in the center drawing in Figure 1 or as shown as 13 in the lower drawing in Figure 1. If the minimum for a specimen is less than the minimum in the table, the cable is not acceptable.

4.8 Assemblies that include single-conductor type UF cables

4.8.1 Single-conductor Type UF cables that individually comply with the requirements in this standard, with or without including other single-conductor cables, may be cabled into assemblies (not to be considered as cables) without overall coverings (an open, skeleton tape or wrap obviously intended only to hold the assembly together is acceptable) and without a bare or covered aluminum or copper-clad aluminum conductor (a bare copper conductor – size is not specified – that is acceptably coated with tin or other suitable metal may be included; such a conductor is not to be covered) if the completed assembly meets the following requirements. Assemblies in which a bare conductor is included are to be tested for dielectric voltage withstand as indicated in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83 after immersion in water for at least 1 h. Assemblies in which a bare conductor is not included may be tested for dielectric voltage withstand (1 h or longer immersion) or spark tested as indicated in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83 (each layer in a multiple-layer assembly is to be sparked separately). Each 14 – 8 AWG conductor in an assembly is to be individually tested for continuity according to 5.2 after the assembly is completed.

5 Test Requirements

5.1 General

Every length of finished insulated conductor shall be capable of complying with the requirements of 5.2 – 5.13, as applicable.

5.2 Continuity

5.2.1 Each circuit conductor and any equipment grounding conductor shall be continuous throughout the entire length of the finished cable or assembly. Finished single-conductor cable and finished multiple-conductor cables and assemblies shall be tested for continuity of each 14 – 10 AWG conductor by the manufacturer at the factory.

5.2.2 Compliance shall be determined according to 8.2.1.

5.3 Vertical flame test

5.3.1 Finished single-conductor cable, finished multiple-conductor cable shall not convey flame, continue to burn for more than 60 s after five 15 s applications of a standard test flame, and drop flaming particles that ignite cotton.

5.3.2 Compliance shall be determined according to 8.3.1.

5.4 Vertical-tray flame test

5.4.1 The range of sizes 14 – 6 AWG of finished multiple-conductor cables that are marked (see 6.1.7 – 6.1.9) for use in cable trays are acceptable where the insulation and jacket on the 14 or 12 AWG size containing two circuit conductors, with or without an equipment grounding conductor, do not exhibit damage that reaches the upper end of any sample after two sets of samples are separately installed in a vertical ladder type of cable tray and subjected to 20 min of flame.

5.4.2 Compliance shall be determined according to 8.4.1.

5.5 Dielectric voltage-withstand test

5.5.1 After immersion in water at room temperature for 24 hr and, while still immersed, specimens of the finished cable wound around an earth-grounded metal mandrel shall withstand for 60 s a 48 – 62 Hz essentially sinusoidal rms potential of 5000 V. The potential in the case of single-conductor specimens shall be applied from the conductor to the earth-grounded water and mandrel and, in each case of multiple-conductor specimens, from each conductor (separately) to the other conductor or conductors, to any equipment grounding conductor, and to the earth-grounded water and mandrel.

5.5.2 Compliance shall be determined according to 8.5.

5.6 Tension and elongation test

5.6.1 Finished multiple-conductor cable shall be capable of withstanding the application of a tension imparted by a weight that exerts 300 lbf (1334 N or 136 kgf) for 60 s without parting, opening up at any point, or showing a permanent elongation of more than 1 in per foot (5 mm per 60 mm) of original specimen length.

5.6.2 Compliance shall be determined according to 8.6.

5.7 Unwinding test at low temperature

5.7.1 After cooling for 4 h to minus 25.0 ±2.0°C, each component of finished single- and multiple-conductor cables shall remain undamaged after the low-temperature unwinding.

5.7.2 Compliance shall be determined according to 8.7.

5.8 Pulling-through-joist test

5.8.1 After being pulled through joists, multiple-conductor cable with a nonintegral jacket and web shall maintain the minimum acceptable separation between circuit conductors shown in Table 3 and, if an equipment grounding conductor is used, the equipment grounding conductor shall not move directly between the circuit conductors, and the metal of the equipment grounding conductor shall not touch circuit-conductor insulation.

5.8.2 Compliance shall be determined according to 8.8.

5.9 Impact test

5.9.1 Finished 6 AWG single-conductor cable, finished multiple-conductor cable containing two 14 or 12 AWG copper circuit conductors with or without an equipment grounding conductor, and finished multiple-conductor cable containing two 12 AWG copper-clad aluminum or aluminum circuit conductors with or without an equipment grounding conductor shall withstand the impact energy and subsequent application of an rms potential of 6000 V (dielectric voltage-withstand test required only for multiple-conductor cable) indicated in Table 7.

5.9.2 Compliance shall be determined according to 8.9.

5.10 Crushing resistance test

5.10.1 An average force of not less than 1700 lbf (7562 N or 771 kgf) shall be needed to crush finished 6 AWG copper, copper-clad aluminum or aluminum single-conductor cable. The results shall be considered representative of the performance of all 14 – 4/0 AWG single-conductor cables.

5.10.2 An average crushing force of not less than 4500 lbf (20017 N or 2041 kgf) applied flatwise and not less than 1200 lbf (5338 N or 544 kgf) applied edgewise shall be needed to crush a flat cable. The results on flat cable containing two 14 or 12 AWG copper or 12 AWG aluminum circuit conductors with or without an equipment grounding conductor shall be considered representative of the performance of all 14 – 6 AWG multiple-conductor flat cables containing two or three circuit conductors with or without an equipment grounding conductor.

5.10.3 Compliance with the requirements in 5.10.1 shall be determined according to 8.10.1.

5.10.4 Compliance with the requirements in 5.10.2 shall be determined according to 8.10.2 – 8.10.5.

5.11 Overload test

5.11.1 Finished cables containing two or three 14 AWG copper or 12 AWG copper-clad aluminum or aluminum circuit conductors with or without an equipment grounding conductor shall withstand an overload current of 40.0 A and subsequently shall withstand a 48 – 62 Hz essentially sinusoidal rms potential of 5000 V applied for 60 s.

5.11.2 Compliance with 5.11.1 shall be determined in accordance with 8.13.

5.12 Sunlight resistance test

5.12.1 The ratio of the average tensile strength and ultimate elongation of five conditioned specimens to the average tensile strength and ultimate elongation of five unconditioned specimens shall be as follows:

- a) 0.85 or more for specimens from cable whose outer surface is marked "sunlight resistant" in accordance with 6.1.6. The specimens shall be conditioned for 300 h of xenon-arc exposure.
- b) 0.80 or more for specimens from cable whose outer surface is marked "sunlight resistant, for CT use" or "sunlight resistant, for use in cable trays" in accordance with 6.1.7. The specimens shall be conditioned for 720 h of xenon-arc exposure.

5.12.2 Compliance shall be determined according to 8.12.

5.13 Durability of ink printing

5.13.1 Printing on the finished wire shall remain legible after being conditioned in accordance with 5.13.2 and 5.13.3.

5.13.2 One of the specimens shall be aged in a full-draft circulating-air oven with 100 – 200 fresh-air changes per hour; the other left at room temperature for 24 h in still air at $23.0 \pm 5.0^\circ\text{C}$ before being tested. The time and temperature shall be in accordance with the air oven aging conditions corresponding to the rated temperature printed on the outer surface of the insulation or jacket material. The specimen shall then be removed from the oven and kept in still air to cool to room temperature for 60 min before being tested.

5.13.3 The temperature and time for accelerated aging in circulating-air oven for conditioning shall be as specified in Table 11 of UL 83 for the insulation and as specified in Table 6 of this Standard for the jacket.

5.13.4 Compliance with 5.13.1 – 5.13.3 shall be determined in accordance with 8.11.

6 Markings

6.1 Markings on product

6.1.1 All printing on the outer surface of finished cable or anywhere within a cable shall be repeated at the following intervals throughout the length of the cable:

- a) Size shall be repeated at intervals that are not longer than a nominal 24 inches (610 mm).
- b) The marking in 6.1.11 for identification of copper-clad aluminum shall be repeated at intervals that are not longer than 6 in (150 mm).
- c) All information other than size and the identification of copper-clad aluminum shall be repeated at intervals that are not longer than 40 in (1.02 m).

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