UL 493

STANDARD FOR SAFETY

Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables

UL Standard for Safety for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables, UL 493

Tenth Edition, Dated December 10, 2018

Summary of Topics

This revision of ANSI/UL 493 dated March 11, 2021 includes a modification to 4.6.3.2.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal (s) on this subject dated November 6, 2020.

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Standard for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables

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The most recent designation of ANSI/UL 493 as an American National Standard (ANSI) occurred on March 11, 2021. 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 https://csds.ul.com.

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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 WireASTM 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 ±1.0° 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 mutiple-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. 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. The cable shall be constructed so that the equipment grounding conductor maintains its location between the two 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 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

5.1.1 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.

5.3.3 Where multiple-conductor cable is being tested, two specimens 18 inches or 455 mm long are to be cut from a sample length of the finished cable. The insulated circuit conductors are to be removed from one of the two specimens, and any glass covering over the insulation is to be removed before the conductors are tested. The other specimen is to be tested with the conductors in place.

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.

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 forced air-circulating oven; the other left at room temperature for 24 h in still air at 23.0 ±5.0°C before being tested. The time and temperature shall be in accordance with the forced air-circulating 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).

d) Date of manufacture by month and year (or in the sequence month, day and year), if not marked on packaging according to 6.2.8.

6.1.2 An insulated conductor intended for use as an equipment-grounding conductor shall be green throughout the entire length and circumference of its finished outer surface with or without one or more straight or helical, continuous or non-continuous yellow stripes. See 6.1.5 for details on stripes. In the case of the flat, webbed cable that includes an insulated equipment-grounding conductor, the equipment grounding conductor shall be identified as such either as indicated above in this paragraph or by means of readily legible, durable ink printing of "grounding only" or an equivalent wording on the outer surface of the finished conductor.

6.1.3 An insulated conductor intended for use as a grounded circuit conductor shall be white or gray throughout the entire length and circumference of its finished outer surface, or shall be identified by three continuous straight or helical, white or gray stripes on other than green insulation, along its entire length. See 6.1.5 for details on stripes. Straight stripes are to be placed a nominal 120° apart. Where multiple grounded circuit conductors are used in a cable, no more than one shall employ white or gray stripes. A white or gray conductor intended for use where different systems are installed in the same raceway, box, gutter or other wiring enclosure shall have a raised tracer or one or more continuous or non-continuous straight or helical stripes that are of even or varying width and of a contrasting color other than green (see 6.1.5).

6.1.4 An insulated conductor intended for use as an ungrounded insulated circuit conductor shall be finished to show a color or combination of colors other than and in contrast with white, gray, and green. The outer surface so colored also complies with the intent of this requirement where it contains any one of

the following throughout the length of the cable in a color or combination of colors other than and in contrast with white, gray, and green:

a) One or more continuous or non-continuous straight or helical stripes.

b) An unbroken series of identical hash marks or other symbols with dimensions as specified for stripes and with regular spacing.

c) Numerals, letter, words, or a combination thereof that comply with this Standard.

See 6.1.5 for details on stripes.

The markings covered in this paragraph shall not conflict or be confused with any of the other markings required or otherwise covered in this Standard.

6.1.5 Stripes as specified in 6.1.2 – 6.1.4 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 in the case of a yellow stripe(s) or a total of 15 – 70 percent of the calculated circumference of the outer surface of the finished insulated conductor in the case of white or gray stripes, with no individual width less than 5 percent of that same circumference. The width shall be measured perpendicular to each stripe. Where non-continuous stripes are appropriate, they shall consist of a series of identical marks and spaces, the length of each mark shall be at least 1/8 inch (3 mm) and the linear spacing between marks shall not be greater than 3/4 inch (19 mm).

6.1.6 Cable that complies with the 300 h test requirements in 5.12.1 may have a durable marking on the outside surface of the cable consisting of the words "sunlight resistant".

6.1.7 The designation "sunlight resistant, for CT use" or "sunlight resistant, for use in cable trays" may be marked on the outer surface of finished 14 – 6 AWG cables that contain two or three circuit conductors with or without an equipment grounding conductor if finished cable containing two 14 or 12 AWG circuit conductors with or without an equipment grounding conductor complies with the flame tests referenced in 5.4 and with the 720 h sunlight-resistance requirements in 5.12.1. Where the cable is tested to the FT4/IEEE 1202 Vertical tray flame test, the cable may additionally be marked "FT4/IEEE 1202" or "FT4".

6.1.8 The designation "for CT use" or "for use in cable trays" may be marked on the outer surface of finished 14 – 6 AWG cables that contain two or three circuit conductors with or without an equipment grounding conductor if finished cable containing two 14 or 12 AWG circuit conductors with or without an equipment grounding conductor complies with the flame tests referenced in 5.4, but have not been tested for sunlight resistance or do not comply with the 720 h sunlight-resistance requirements in 5.12.1. Where the cable is tested to the FT4/IEEE 1202 Vertical tray flame test, the cable may additionally be marked "FT/IEEE 1202" or "FT4".

6.1.9 Single-conductor cable shall not be marked for use in cable trays.

6.1.10 Finished cable shall have a durable marking on the outside surface of the cable consisting of the following:

a) The letters "UF-B" for multiple conductor cable with 90° C insulation and "UF" for all other multiple-conductor cable and for single-conductor cable (only one type-letter designation shall be marked on any cable);

b) The AWG size and number of the insulated circuit conductors (the number of conductors is not required on a single-conductor cable);

c) The maximum working potential "600 volts" or "600 V"; and

d) The name of the cable manufacturer, that cable manufacturer's trade name for the product, or both, or any other acceptable distinctive marking by means of which the organization responsible for the cable can readily be identified. When the organization that is responsible for the cable is different from the actual manufacturer, both the responsible organization and actual manufacturer shall be identified by name or by appropriate coding such as by trade name, trademark, the assigned electrical reference number, or the assigned combination of colored marker threads. The meaning of any coded identification shall be made available. A private labeler may also be identified.

No surface markings shall include temperature or ampacity rating.

6.1.11 The outer surface of the insulation on each copper-clad aluminum conductor in a multiple-conductor cable and the outer surface of the integral insulation and jacket on each copper-clad aluminum single-conductor cable shall be durably and legibly printed at intervals not exceeding 6 inches (150 mm) throughout the entire length of the cable with the AWG size of the conductor and with one of the following designations:

a) "AL (CU-CLAD)";

b) "ALUMINUM (COPPER-CLAD)";

c) "CU-CLAD AL"; or

d) "COPPER-CLAD ALUMINUM".

In the cases of a single-conductor cable and a circuit conductor in a multiple-conductor cable, one or more orange stripes of even or varying width are acceptable in place of or in addition to the word identification of the conductor metal. One or more orange stripes shall not be used on an equipment grounding conductor. Wherever used, one or more orange stripes shall be straight and shall occupy a total width – the width shall be measured perpendicular to the longitudinal axis of each stripe, not necessarily around the conductor circumference – of 5 – 70 percent of the calculated circumference of the outer surface of the finished conductor or single-conductor cable and an individual width that is not less than 5 percent of the calculated circumference of the finished outer surface. One or more orange stripes used in place of word identification of the conductor metal may be broken only by the AWG size designation. One or more orange stripes used in addition to word identification of the conductor metal may be broken only by the AWG size designation and the work identification of the conductor metal.

6.1.12 Embossed (raised) lettering is acceptable. Indent printing is acceptable if the thicknesses of the PVC integral insulation and jacket on single-conductor cables and if the PVC jacket on multiple-conductor cables are not reduced below the average and minimum at any point shown in Table 1 and Table 6 as being the thinnest acceptable. Ink printing is acceptable.

6.1.13 If the organization responsible for the product produces a cable or cables covered in this standard in more than one factory, each of that organization's finished Type UF cables shall have a permanent distinctive marking throughout its entire length by means of which the finished cable can be identified readily as the product of a particular factory. Except in the case of single-conductor cable, the identifying marker for the finished cable shall not be located under the insulation.

6.1.14 The organization responsible for the insulated conductors, if other than the organization responsible for the finished cable, may use indelible ink printing on the surface of each of the insulated conductors as the means for its identification and the factory identification. Such printing shall appear in conjunction with the identification of the organization responsible for the cable and shall appear at the intervals mentioned in 6.1.1. The printing shall consist of an identification of the organization responsible for the circuit conductors and an identification of the factory (if the organization operates more than one).

No other wording or identification of the organization responsible for the circuit conductors shall appear in the printing.

6.2 Markings on package

6.2.1 A tag on which the following information is indicated plainly (the sequence of the items is not specified) shall be attached to every shipping length of finished cable. Where the cable is wound on a reel or coiled in a carton, the tag may be eliminated and the information printed or stenciled directly onto the reel or carton. Other information, where added, shall not confuse or mislead (see 6.2.5 – 6.2.7) and shall not conflict with these requirements. See 6.2.8 for date marking.

a) "600 volts" or "600 V".

b) The name of the cable manufacturer, that manufacturer's trade name for the cable, or both, or any other appropriate distinctive marking by means of which the organization responsible for the cable is readily identifiable. Where the organization that is responsible for the cable is different from the actual manufacturer, both the responsible organization and the actual manufacturer shall be identified by name or by appropriate coding such as by trade name, trademark, the assigned electrical reference number, or the assigned combination of colored marker threads. The meaning of any coded identification shall be made available by the organization responsible for the cable. It is appropriate also to identify a private labeler; the means is not specified.

c) The marking "UF-B" for multiple-conductor cable with 90° C insulation and "UF" for all other multiple-conductor cable and for single-conductor cable (see 6.1.12).

d) The AWG size of the circuit conductors and the quantity of circuit conductors.

6.2.2 If an aluminum conductor or conductors are used, the AWG size of the circuit conductors shall be followed by the word "aluminum" or the abbreviation "AL" shall appear in the marking on tags, reels, and cartons.

6.2.3 If a copper-clad aluminum conductor or conductors are used, the AWG size of the conductors, wherever the size appears (on the tag, reel, or carton), shall be followed by one of the designations, "AL (CU-CLAD)", "ALUMINUM (COPPER-CLAD)", "CU-CLAD AL", or "COPPER-CLAD ALUMINUM". Tags, reels, and cartons for copper-clad aluminum cable shall have the following markings:

a) "Copper-clad aluminum shall be used only with equipment marked to indicate that it is for use with copper-clad aluminum conductors. Terminate copper-clad aluminum with pressure wire connectors marked 'AL-CU' or 'CC-CU'."

b) For 12 – 10 AWG solid copper-clad aluminum "May be used with wire-binding screws and in pressure-plate and push-in spring-type connecting mechanisms that are acceptable for use with copper conductors."

c) "Where physical contact between any combination of copper-clad aluminum, copper, and aluminum conductors occurs in a wire connector, the connector shall be of a type marked for such intermixed use and the connection shall be limited to dry locations only."

6.2.4 If a compact-stranded copper conductor is used, the AWG size of the conductor – wherever the size appears (on the tag, reel, or carton) – shall be followed by COMPACT COPPER or COMPACT CU. The word COMPACT may be abbreviated CMPCT. Tags, reels, and cartons for compact-stranded copper wire shall have the following marking: "Terminate with connectors identified for use with compact-stranded copper conductors".

6.2.5 A current or temperature designation shall not be included in the marking on the tag, reel, or carton.

6.2.6 The tags, reels, and the like may indicate the conductor type-letter designation, but such designation, if used, shall follow and be separated from the required markings cited in 6.2.1. The conductor type-letter designation may be marked on the outside surface of each insulated circuit conductor in multiple-conductor cable that are marked "UF" but not in those marked "UF-B". Wherever the cable type-letter designation appears, no other letters, figures, or symbols shall appear in conjunction with the cable type letters.

Note: This requirement is intended to indicate that a clear marking of the cable type-letter designation is required and that the use of suffix letters, numerals, or other symbols in proximity to the type letters is precluded where such use would be confusing in any way. In the legend on a cable, for example, "UF-B 8 AL" is not acceptable, but "UF-B – 8 AL" is acceptable.

6.2.7 The markings on coils, reels, and cartons of flat UF-B cables, containing 14 – 10 AWG copper circuit conductors, or 12 – 10 AWG copper-clad aluminum or aluminum circuit conductors, or on the tags attached thereto, may include the statement "Also for use as Type NMC-B cable" or "Also for use as NMC-B cable" if the added statement is separated from (and preferably follows) the required markings indicated in 6.2.1.

6.2.8 The date of manufacture by month and year (or in the sequence month, day, and year) shall be included among the tag, reel, or carton markings described in 6.2.1, or shall be included among the cable markings described in this Standard where legible on the outer surface of the cable. The date shall be shown in plain language, not in code.

6.2.9 A statement shall appear on tags, and on all reels, cartons, and other packaging containing the circuit conductors to indicate that the conductors contained therein are intended for further processing.

7 Deep-Well Submersible Pump Cable

7.1 Conductors

7.1.1 The circuit conductors in a cable for use within well casings for wiring deep-well submersible water pumps shall consist of single-conductor Type UF cables having solid or stranded 14 – 2 AWG copper or 12 – 2 AWG aluminum or copper-clad aluminum conductors. Circuit conductors 1 – 4/0 AWG shall be stranded.

7.1.2 An equipment grounding conductor is not required. Where used, an equipment grounding conductor shall consist of a fully insulated solid or stranded conductor that is of the same type as the circuit conductors, is of a size that is not smaller than indicated in Table 8 or Table 9, for the largest size circuit conductor used, and is identified as indicated in 6.1.2.

7.1.3 See 5 for the long-term evaluation of an insulation or jacket material other than PVC or of PVC that does not comply with the specified short-term tests.

7.2 Assembly

7.2.1 The circuit and equipment grounding conductors shall be assembled in one of the following ways:

a) Two through six circuit conductors plus any equipment grounding conductor are to be cabled (length of lay not specified) with an overall covering. The overall covering shall consist of a PVC jacket complying with the requirements in this Standard, including the jacket thicknesses in Table 10, for the largest size circuit conductor used, and the physical properties in Table 2.

b) Two through six circuit conductors plus any equipment grounding conductor are to be cabled (length of lay not specified) without an overall covering.

c) Two or three circuit conductors plus any equipment grounding conductor are to be laid flat and parallel to one another with an interconnecting web between adjacent conductors extruded simultaneously with the insulation and jacket. Polarity identification of each circuit conductor shall be present and shall consist of ridges, surface striping, or word printing. The minimum thickness at any point of the integral insulation and jacket on each circuit conductor and any equipment grounding conductor after separation shall not be less than the minimum thickness at any point indicated for the integral insulation and jacket of single-conductor Type UF cable of the same construction.

d) Two or three circuit conductors plus any equipment grounding conductor are to be laid flat and parallel to one another with a nonintegral, overall PVC jacket complying with the requirements in this Standard, including the jacket thicknesses in Table 10 and the physical properties in Table 2. There shall be an interconnecting web between adjacent conductors. The web shall be integral with the jacket. The thickness of the web is not specified.

7.3 Marking

7.3.1 In addition to the applicable markings required in Markings, Section 6, the markings in 7.3.2 – 7.3.4 shall apply.

7.3.2 The outer surface of the overall covering on a pump cable of any of the constructions detailed as specified in 7.2 (a), (c), and (d) shall be durably and legibly marked "submersible pump cable". If each circuit conductor is not surface-marked with its type-letter designation, the marking on the outer surface of the pump cable shall include the conductor type letters.

7.3.3 The surface of single-conductor Type UF cable intended to be used in submersible water pump cable may be durably and legibly marked "pump cable". In a pump cable without an overall covering, the surface of each circuit conductor shall be durably and legibly marked with the conductor type letters.

7.3.4 For submersible water-pump cable the tag shall also include the following wording: "For use within the well casing for wiring deep-well water pumps where the cable is not subject to repetitive handling caused by frequent servicing of the pump units."

7.4 Tests

The completed cable shall be subjected to the tests in Test Requirements, Section 5.

8 Test Methods

8.1 General

The test methods for determining compliance with the requirements in Test Requirements, Section 5 are presented in 8.2 – 8.13.

8.2 Continuity test

8.2.1 Testing shall be performed in accordance with the test, Continuity, Method 2 (eddy current) in UL 2556.

8.2.2 For the factory production continuity testing, the manufacturer may elect to substitute a continuous eddy-current procedure as indicated in the test Continuity, Method 2 (eddy current), in UL 2556.

8.3 Vertical flame test

8.3.1 Compliance shall be determined by cutting two specimens 18 inches (455 mm) long from a sample length of the finished cable, and removing the insulated conductors from one specimen and testing the conductors individually. An additional specimen shall be tested as a complete cable.

8.3.2 Testing shall be conducted according to the test, FV-1/Vertical Flame, in UL 2556.

8.4 Vertical-tray flame test

8.4.1 Testing shall be performed according to UL 1685, as indicated under "UL Flame Exposure" or "FT4/IEEE 1202 Type of Flame Exposure" (smoke measurements are not applicable).

8.5 Dielectric voltage-withstand test

8.5.1 The apparatus is to consist of an immersion tank; a set of metal mandrels, each a right-circular cylinder having a diameter equal to seven times the diameter or length of minor axis of the cable with which it is used; and a supply circuit, circuit breaker, and voltmeter as described in 8.5.2.

8.5.2 The rms test potential is to be obtained from a 48 – 62 Hz supply whose output potential is continuously variable from near zero to at least 5000 V at a rate that is not greater than 500 V/s. With a specimen in the circuit, the supply potential is to have a crest factor (peak voltage divided by rms voltage) equal to 95 – 105 percent of the crest factor of a pure sine wave over the upper half of the output range. The supply voltage is to be monitored continuously by a voltmeter that, if of the analog rather than digital type, shall have a response time that does not introduce a lagging error greater than 1 percent of full scale at the specified rate of increase in voltage, and that has an overall accuracy that does not introduce an error exceeding 5 percent. The maximum current output of which the supply is capable is to enable routine testing of full reels of the cable without tripping of the circuit breaker by the charging current.

8.5.3 A specimen of finished cable of a length for making seven or more turns around the applicable diameter of mandrel plus 28 inches (711 mm) is to be opened at each end so that the insulated circuit conductors extend 4 inches (102 mm) from the rest of the cable. The insulation is not to be damaged. At one end of the specimen, each of the circuit conductors and any equipment grounding conductor are to be bared for 1 inch (25 mm) to facilitate connection to the testing circuit. The specimen of cable is then to be wound onto the mandrel starting at the center of the specimen and winding simultaneously toward each end. The ends are then to be secured so that not less than a 10-inch (254-mm) length of cable extends away from the mandrel at each of the coil. The specimen and the mandrel on which it is wound are then to be immersed in tap water at room temperature for 24 h. During the immersion, the ends of the coil are to extend at least 8 inches (200 mm) above the surface of the water, and care is to be taken that the ends do not become wet. After the coil has been immersed for 24 h, and while it is still immersed, the potential is to be increased from near zero at an essentially uniform rate in the range of 10 – 60 V/s. The increase is to continue in this manner until the voltage is 5000. If the 5000 V level is reached without a breakdown, the voltage is to be held constant at that level for 60 s and is then to be reduced to near zero at an essentially uniform rate in the range of 10 – 60 V/s. The cable is not acceptable if, during any application of voltage, breakdown occurs in less than 60 s at 5000 V or while the voltage is being increased or decreased.

8.6 Tension and elongation test

8.6.1 The apparatus is to consist of a pair of clamps, a weight that exerts a pull of 300 lbf (1334 N or 136 kgf), and a differential pulley or a block and tackle for raising the specimen and weight gently and gradually. The clamping arrangement shall be such that the cable is securely held in place so that there isn't any slippage or breakage at the clamps.

8.6.2 A specimen of finished cable approximately 4-1/2 ft (1.4 m) long is to be secured in the clamps so that somewhat more than 36 inches (900 mm) of cable extends between the clamps. Two fine marks are to be placed on the cable 36 inches (900 mm) apart, penciled lines on the surface of the cable at such point are acceptable as markers.

8.6.3 The upper clamp is to be raised gently by means of the differential pulley or block and tackle until the weight is supported by the specimen and is a short distance from the floor. The method to be used is shown in Figure 2. The weight is to be supported in this manner clear of the floor for 60 s and then lowered to the floor to release the tension. Sixty seconds after removal of the load, the distance between the marks is to be measured again. The specimen is then to be examined for damage.

8.6.4 The cable is not acceptable if a specimen parts, opens up at any point, or shows a permanent elongation of more than 1 inch per foot of original specimen length between the marks or more than 5 millimeters per 60 millimeters of the original specimen length between the marks. The interior of the cable need not be examined.

8.7 Unwinding test at low temperature

8.7.1 Preparation of specimens

8.7.1.1 Two straight specimens of a representative size from Table 11, at least 36 inches (1 m) long are to be cut from a sample length of finished cable without bending the cut ends of the conductor or conductors. The specimen chosen shall be representative of that size and larger conductor sizes.

8.7.2 Test equipment

8.7.2.1 The apparatus for this test is to consist of a mandrel 3/4 ±1/64 inch (19 ± 0.4 mm) in diameter and a chamber capable of sustained operation at a low temperature of minus 25.0 ±2.0° C. An accurate thermometer or other means of continuous, accurate indication of the temperature in the cold chamber is to be provided, and its indications are to be clearly legible from outside the chamber.

8.7.2.2 Means are to be provided for securing the mandrels within the cold chamber in a manner that enables the unwinding operation to be conducted in the chamber at the low temperature. There is to be space below the mandrels to enable the weighted specimens to hang freely without touching one another or the walls or floor of the chamber as and after they are unwound. Space is to be provided for removal of the unwound specimens from the opened chamber and their separation from the mandrels for examination without damage or stress to the insulation in the course of the removal and separation.

8.7.2.3 Weights in accordance with Table 11 are to be provided.

8.7.3 Procedure

8.7.3.1 The empty cold chamber is to be precooled to the low temperature before the specimens are wound onto the mandrels and put into the chamber.

8.7.3.2 While the specimens and the mandrels are at room temperature, one end of each specimen is to be secured to the mandrel and each specimen is to be wound onto the mandrel for five full turns with adjacent turns touching. The assemblies of mandrel and specimen are to be placed in the precooled chamber. The weight indicated in Table 11 is to be attached to each specimen and left attached throughout the cooling period and during the unwinding.

8.7.3.3 After the 4 h, and while the chamber remains at the low temperature, the specimens (with the weights attached) are to be unwound from the mandrels at the rate of 4 – 6 turns per minute. Without

damaging the specimens, the weights are then to be detached and the specimens are to be removed from the chamber.

8.7.3.4 During the loading of the cold chamber and the unwinding of the specimens, the temperature in the chamber is not to rise above minus 22.0°C

8.7.4 Results

8.7.4.1 Two specimens are to be cut open and their interiors examined for damage as described in 8.7.4.2.

8.7.4.2 Any cable from which a specimen exhibits inside or outside cracks, tears, splits, or other openings or any internal cracking in the insulation or in the overall PVC jacket is not acceptable. Internal cracks are those within the thickness of the insulation or jacket as evidenced by slight depressions (checks) in the outer surface.

8.8 Pulling-through-joists test

8.8.1 The joists are to be simulated by four straight, knot-free 6-inch (150-mm) or longer lengths of Douglas fir 2-by-4 kiln-dried lumber [actual cross section measures 1-1/2 by 3-1/2 inches (38 by 89 mm)]. Both ends of each length are to be cut perpendicular to the long surfaces.

8.8.2 By means of a power wood auger, three holes, each 5/8 inch (16 mm) in diameter, are to be bored (at a speed of approximately 1800 r/m) through the broad faces of each length of 2 by 4 as shown in Figure 3. The longitudinal axes of the holes are to be parallel and at an angle of 15° to the horizontal, as shown in the end view, and 1-1/2 inches (38 mm) apart. An attempt is not to be made to smooth or round the edges of the holes or to remove splintered wood, sawdust, or drilling chips from the holes.

8.8.3 As illustrated in Figure 3, an open, rigid, metal frame is to be provided on which four of the 2 by 4's are to be supported on edge (width of broad faces vertical) approximately 8.5 ft (2.6 m) above the floor of the test room with their center lines 16 inches (406 mm) apart and parallel to one another in a horizontal plane. The 2 by 4's are to be secured to the frame with all of their holes inclined in the same direction (longitudinal axes of holes parallel, see the four end views in Figure 4) and progressively offset a horizontal distance of 6 inches (150 mm) as shown in the top view of Figure 4, which is a view looking down from above the 2 by 4's.

8.8.4 A 250-ft (75-m) coil of finished cable that contains two 14 or 12 AWG copper or 12 AWG copper-clad aluminum or aluminum insulated circuit conductors with or without an equipment grounding conductor and is at room temperature and in its carton, is to be placed flat on the floor and the inner circle is to be removed from the carton to make the inner end of the cable accessible. The carton is to be positioned flat on the floor to make the vertical distance between the bottom of the carton and the horizontal plane containing the centerlines (see Figure 3) of the 2 by 4's and the horizontal distance between the first 2 by 4 and a vertical line perpendicular to the center of the carton such that the cable enters the joists at an angle of approximately 77° to the vertical. Typical dimensions are 23 inches by 100 inches (583 mm by 2.5 m) as shown in Figure 3 or 18 inches by 80 inches (457 mm or by 2.0 m) as used in low-temperature testing of other cables.

8.8.5 One end of the cable is to be threaded in succession through the holes labeled A, B, C, and D in Figure 4. As soon as the cable has been threaded through the four holes, the end of the cable emerging from hole D is to be grasped securely by one or two people standing on the floor in a position such that the cable emerges from hole D at an angle of about 45° to the vertical. While maintaining this angle, they are to pull (hand-over-hand whenever possible) 50 ft (15 m) of the cable entirely through the holes until the end of this length of cable emerges from hole D. The cable is to be pulled through within 30 s, and no effort is to be made to uncoil, untwist, or otherwise straighten or adjust the cable except to remove kinks that

would keep the cable from being pulled completely through the four holes. All of the pulling is to be done from beyond hole D, none from between the 2 by 4's.

8.8.6 As soon as 50 ft (15 m) of the cable emerges from hole D, that initial test length is to be cut off and set aside. The cable extending from hole D back through holes C, B, and A are to be cut off and discarded.

8.8.7 A second 50 ft (15 m) of cable from the coil is to be pulled through holes E, F, G, and H. As soon as 50 ft (15 m) of the cable emerges from hole H, that second test length is to be cut off and set aside. The cable extending back through holes H, G, F, and E to the coil is to be cut off and discarded.

8.8.8 A third (and final) 50 ft (15 m) of the cable from the coil is to be pulled through holes I, J, K, and L. As soon as 50 ft (15 m) of the cable emerges from hole L, the third test length is to be cut off and set aside.

8.8.9 The 36 inch (1 m) section of the cable that shows the most scuffing, abrasion, twisting, and/or disturbance of the conductor configuration is to be cut from each test length. The most severely scuffed, abraded, twisted, and/or disturbed portion of each test length is to be cut from the 36 inches (1 m) section. The portion cut from the section is to be 10 inches (250 mm) long, with the scuffing, etc. occupying the center of its length. These portions are to be examined at both ends for maintenance of the separation measured between adjacent surfaces of the metal of the circuit conductors. If the separation is less than indicated in Table 3, the separation is to be recorded as not acceptable. The jacket is to be slit longitudinally along both of the curved edges of the cable and, with the portion lying flat on a horizontal surface, the uppermost flat half of the jacket is to be lifted off to expose the interior of the cable. The cable interior is not to be disturbed while the jacket is slit and its upper half is removed. If the cable contains an equipment grounding conductor, the interior of the portion is to be examined for maintenance of the position of the equipment grounding conductor. Spacers and fillers may be removed during this examination. If the equipment grounding conductor has moved directly between the circuit conductors, this result is to be recorded as not acceptable. If the metal of the equipment grounding conductor is touching the insulation on a circuit conductor, this result is to be recorded as not acceptable. If any of the three examinations described in this paragraph show unacceptable results, one additional 36 inch (1 m) section is to be cut from each cable test length from which unacceptable results were obtained. These additional section(s) are to be the severely scuffed, abraded, twisted, and/or disturbed portions of the test lengths. Each additional section is to be examined as described in this paragraph. The cable is not acceptable if unacceptable results are shown in any of the three examinations of any additional sections.

8.9 Impact test

8.9.1 In accordance with the specifications shown in Table 7, each of a number of specimens of finished multiple-conductor cable is to be subjected to the impact energy of a weight falling freely to strike the cable where it is laid over a steel mandrel that is 3/4 inch (19 mm) in diameter and rests on a solid steel plate. The longitudinal axis of the cable is to be held perpendicular to the axis of the mandrel, and both axes are to be in a horizontal plane. A weight of steel in the form of a solid right-circular cylinder having a diameter of 1-1/4 inches (32 mm) is to be used, and the flat end of the weight is to strike the cable.

8.9.2 Specimens of finished single-conductor cable are to be subjected to impact with the mandrel replaced by a flat steel plate of dimensions that provide a firm base for the impact.

8.9.3 Following the impact on multiple-conductor cable, all coverings except the insulation are to be removed from the specimens without damaging the insulation. Each insulated circuit conductor and any insulated equipment grounding conductor is then to be bent through 180° around a mandrel 1 inch (25 mm) in diameter with the portion of the wire that received the impact at the center of the bend. The bend of each U-shaped specimen thus formed is to be buried in lead shot and a 48 – 62 Hz essentially sinusoidal rms potential is to be applied between the shot and the metal conductor. The potential is to be increased from near zero at an essentially uniform rate in the range of 10 – 60 V/s. The increase is to continue in this manner until the rms voltage is 6000. If the 6000-V level is reached without breakdown, the voltage is to be held constant at that level for 5 s and is then to be reduced to near zero at the rate mentioned above. The

cable is acceptable if breakdown occurs at less than 6000 V while the rms potential is being increased or decreased or in less than 5 s at 6000 V in not more than the number of insulated conductors indicated in the bottom row of Table 7.

8.9.4 For single-conductor cable, unacceptable performance is to be recorded if a rupture of the PVC occurs through which the conductor is visible or if, during the impact, the conductor contacts the flat steel plate or the weight as indicated by a 3-W, 120-V, neon lamp connected in series with the conductor of the specimen under test and the energized conductor of a 120-V, 48 – 62 Hz, AC supply circuit. The weight and all metal parts of the impact apparatus are to be connected together, to earth ground, and to the grounded supply wire.

8.10 Crushing resistance

8.10.1 Ten specimens of single conductor cable shall be tested according to the test, Crush Resistance (Method 1), in UL 2556.

8.10.2 Twenty specimens of finished flat cable, each of a convenient length, are to be tested. Each specimen is to be placed between steel plates that are 2 inches (50 mm) wide, flat, and horizontal in a compression machine, the jaws of which are to close at the rate of 0.50 ±0.05 in/min (10 ±1 mm/min). The steel plates and any equipment grounding conductor are to be connected together and to earth ground. The cable, the apparatus, and the surrounding air are to be in thermal equilibrium with one another at a temperature of 23.0 ±2.0°C throughout the test.

8.10.3 The specimen is to be subjected to an increasing force until contact occurs (as indicated by low-voltage buzzer circuits) between two circuit conductors or between one or more circuit conductors and any equipment grounding conductor, the earth-grounded frame of the testing machine, or both.

8.10.4 Ten specimens of flat cable are to be tested by applying the crushing force with the cable lying flatwise between the plates with the length of the cable parallel to the 2 inches (50 mm) dimensions of the plates. The remaining ten specimens are to be tested by applying the crushing force with the cable held edgewise between the plates with the length of the cable parallel to the 2 inches (50 mm) dimensions of the plates. In the latter case, for each trial, the cable, with its axis horizontal and its flat faces vertical, is to be gripped at points 3 inches (75 mm) to each side of the section of cable to be crushed and manually twisted by turning the cable 90° in opposite directions. The flat faces thus remain vertical at the midpoint and the opposite flat faces are up and horizontal. Half of the ten specimens are to be twisted in a clockwise direction about the axis, and the remaining five specimens are to be twisted in the opposite direction. In the case of each edgewise specimen, the vertical flat faces of the cable are to be at the center of the plates.

8.10.5 The force at which the contact mentioned in 8.10.2 occurs is to be recorded in each case. The cable is not acceptable if the averages calculated from these forces are less than indicated in 5.10.1 or 5.10.2.

8.11 Overload test

8.11.1 An 11-ft (3.35-m) specimen of finished cable is to be laid flat and tested on a horizontal board. A second specimen of a convenient length is to be tested on two wooden blocks 2 by 2 inches (51 by 51 mm) in cross section and of any convenient length. As shown in Figure 5, the blocks are to be secured parallel to one another and with their outer faces 8 inches (203 mm) apart. The outer edge of each block is to be notched to accommodate a steel rod 1/16 inch (1.5 mm) in diameter. The cable is to be laid over the blocks and is to be bent down over the rods to form an inverted U. A weight that exerts 5 lbf (22.2 N or 2.27 kgf) is to be attached to each end of the specimen and the circuit conductors are to be connected in series. Any equipment grounding conductor is not to be in the circuit.

8.11.2 A current of 40.0 A is to be passed through the circuit conductors at low voltage for 60 min, after which the specimens are to cool to room temperature in still air without being disturbed.

8.11.3 The specimens are then to be coiled and immersed in tap water at room temperature with the ends of the specimens projecting well away from the water. A 48 – 62 Hz essentially sinusoidal rms test potential of 5000 V is then to be applied between pairs of the circuit conductors and, separately, also between each circuit conductor and the water. The potential is to be increased from near zero at an essentially uniform rate in the range of 10 – 60 V/s. The increase is to continue in this manner until the rms voltage is 5000. If the 5000-V level is reached without breakdown, the voltage is to be held constant at that level for 60 s and is then to be reduced to near zero at an essentially uniform rate in the range of 10 – 60 V/s. The cable is not acceptable if either or both specimens break down at less than 5000 V or in less than 60 s at 5000 V.

8.12 Sunlight resistance test

8.12.1 Compliance shall be determined in accordance with the test, Weather (Sunlight) Resistance, in UL 2556.

8.13 Durability of ink printing

8.13.1 Compliance shall be determined in accordance with the test, Durability of ink printing, in UL 2556, CSA C22.2 No. 2556 or NMX-J-556-ANCE.

Table 1
Minimum acceptable thicknesses of integral insulation and jacket on single-conductor cable

(See 4.4.3)

AWG size of conductor	Minimum average of PVC		Minimum at any point of PVC	
	mils	mm	mils	mm
14 – 10	60	1.52	54	1.37
8 – 2	80	2.03	72	1.83
1 – 4/0	95	2.41	86	2.18

Table 2
Physical properties of PVC jacket

[See 4.5.1, 4.7.2, 7.2.1 (a) and (d)]

Condition of specimens at time of measurement	Minimum ultimate elongation [1 inch (25 mm) bench marks][a]	Minimum tensile strength
Unaged	100 percent [1 inch (25 mm)]	1500 lbf/in^2 or 10.3 MPa
From cable marked "UF–B":		
Aged in a forced air-circulating oven for 240 h at 100.0 ±10°C	Where the specimens are buffed and die-cut, 45 percent of the result with unaged specimens; where the specimens are tubular rather than being buffed and die-cut 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens

Table 2 Continued on Next Page

Table 2 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation [1 inch (25 mm) bench marks][a]	Minimum tensile strength
From cable not marked with the suffix letter "-B":		
Aged in a forced air-circulating oven for 168 h at 100.0 ±1.0°C	Where the specimens are buffed and die-cut, 45 percent of the result with unaged specimens; where the specimens are tubular rather than being buffed and die-cut, 65 percent of the result with unaged specimens.	65 percent of the result with unaged specimens

[a] The methods of preparation of samples, of selection and condition of specimens and of making the measurements and calculations for ultimate elongation and tensile strength are indicated under the heading "Physical Properties Tests of Insulation and Jacket" in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581. Jacket specimens shall have all conductors, insulation, and other parts removed. The cross-sectional area of an irregularly shaped tubular specimen of jacket from a flat cable is to be computed by whichever of the following formulas is applicable:

$$A\ in^2 = \frac{W_g}{163.87G}$$

in which:

A is the cross-sectional area of the specimens in square inches,

W_g is the weight in grams of a 10-inch length of jacket, and

G is the specific gravity of the PVC compound determined by means of Young's gravimeter or the displaced method (in either case, the specimen is to be dipped in alcohol as a wetting agent before the specimen is dipped into water) or;

$$A\ m^2 = \frac{4 \times 10^{-6} W_g}{G}$$

$$A\ cm^2 = \frac{0.04 W_g}{G}$$

$$A\ mm^2 = \frac{4 W_g}{G}$$

in which:

A is the cross-sectional area of the specimen in square meters, square centimeters, or square millimeters;

W_g is the weight in grams of a 250-mm length of jacket; and

G is the specific gravity of the PVC compound determined by one of the means noted above.

Table 3
Minimum acceptable separation of circuit conductors in multiple-conductor cable with or without an equipment grounding conductor

(See 4.6.2.2, 5.8.1, and 8.8.9)

AWG size of circuit conductors	Measured between adjacent surfaces of metal of the circuit Conductors		Measured between centers of the metal of the circuit conductors			
			Class B stranding or compressed stranding		Compact-stranded aluminum	
	inch	mm	inch	mm	inch	mm
14 – 10	0.125	3.2	–	–	–	–
8	–	–	0.328	8.3	0.313	8.0
6	–	–	0.406	10.3	0.391	9.9

Table 4
Equipment grounding conductor in multiple-conductor cable with copper conductors

(See 4.6.3.4)

AWG size of circuit conductors	Smallest acceptable size of equiment grounding AWG conductor
14	14
12	12
10	10
8[a] – 6[a]	10
[a] These conductors are required to be stranded.	

Table 5
Equipment grounding conductor in multiple-conductor cable with aluminum or copper-clad aluminum conductors

(See 4.6.3.4)

AWG size of circuit conductors	Smallest acceptable AWG size of equipment grounding conductor
12	12
10	10
8[a] – 6[a]	8
[a] These conductors are required to be stranded.	

Table 6
Jacket thicknesses

(See 4.7.3, 4.7.5, 4.7.6 and 5.13.3)

AWG size of circuit conductors	Minimum acceptable average thickness of jacket		Minimum acceptable thickness at any point of jacket			
			At any equipment grounding conductor		Elsewhere than at any equipment grounding conductor	
	mils	mm	mils	mm	mils	mm
14 – 10	30	0.76	15	0.38	24	0.61
8 – 6	45	1.14	15	0.38	36	0.91