UL 854

STANDARD FOR SAFETY

Service-Entrance Cables

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UL Standard for Safety for Service-Entrance Cables, UL 854

Twelfth Edition, Dated January 10, 2020

Summary of Topics

This revision of ANSI/UL 854 dated November 27, 2023 includes the following changes:

– Tag Marking; 45.5 and 47.1.

– Requirements in NEC Related to Copper-Clad Aluminum; 6.3.1.

Text that has been changed in any manner or impacted by ULSE'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 March 17, 2023, August 4, 2023 and August 25, 2023.

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The most recent designation of ANSI/UL 854 as an American National Standard (ANSI) occurred on November 27, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 854 on April 23, 1984. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover Type USE and USE-2 (below-ground) and Type SE (above-ground) power cables for installation in accordance with Article 338 and other applicable parts of the National Electrical Code (NEC). These cables are for the service-entrance and other (NEC) uses described in 1.4 – 1.8. In a multiple-conductor cable that is other than submersible-pump cable and does not have a grounding conductor it is appropriate to have one circuit conductor without insulation. It is also appropriate for a submersible pump cable to have a grounding conductor and for Type USE and USE-2 cables to have an insulated grounding conductor. Each insulated conductor in these cables is rated for 600 V. Type USE cable has thermoset insulation, except for the HDPE portion of HDPE-over-XL insulation where used for single-conductor Type USE cable. Type SE cable has thermoset or thermoplastic insulation.

1.2 These cables have insulation of solid, extruded dielectric material(s) that are for use in wet locations at 75°C (167°F) and lower temperatures. Cables that are marked with a conductor type that includes the letters "HH" have insulation that is for use in dry locations at temperatures as high as 90°C (194°F) as well as in wet locations at 75°C (167°F) and lower temperatures. Cables that are marked with a conductor type that includes "-2" have insulation that is for use in wet or dry locations at temperatures as high as 90°C (194°F).

1.3 Cables containing any conductor that is of a metal other than copper are marked to identify the metal as aluminum or copper-clad aluminum. Aluminum single-rated (see 1.4) Type USE or USE-2 cables containing other than solid 12, 10 or 8 AWG conductor(s) are of an EC-1350 grade aluminum alloy or a registered AA-8000 series electrical-conductor-grade aluminum alloy. In all other cables, the aluminum conductor(s) are of a registered AA-8000 electrical-conductor-grade alloy only.

1.4 "Single-rated" Type USE cable is single-conductor, jacketed or coverless multiple-conductor, and submersible-pump cable without any indication of the conductor type letters on type cable, on the individual conductor(s), or on the tag, reel, or carton. "USE" is the only type designation associated with the cable. See 40.4.

1.5 Type SE cables that are not marked with conductor type letters or are marked with conductor type letters alone ("XHHW", "RHW", or "RHH OR RHW" not followed by "cdrs" or the like) have insulated conductors that do not comply with the Thermoset-Insulated Wires and Cables, UL 44, horizontal flame test. Type SE cables that are marked for use in cable trays comply with a 70,000 Btu/h (20.5 kW) vertical-tray flame test as described in Sections 4 – 11 of the Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685 or the FT4/IEEE 1202 flame test as described in Sections 12 – 19 of UL 1685. Smoke measurements are not applicable. See 31.1.

1.6 The outer surface of each single- and multiple-conductor cable that is marked for sunlight-resistance use and the outer surface of each Type SE cable that is marked for sunlight-resistance use in cable trays complies with a 720 h sunlight-resistance test. Each insulated conductor under an overall covering on such multiple-conductor cable complies with a 300 h sunlight-resistance test. All other cables are not marked "sunlight resistant" however they comply with a 300 h or equivalent (see 30.3.2) sunlight-resistance test (each insulated conductor complies and, except in the case of submersible pump cable, any overall covering also complies).

1.7 Type USE and USE-2 cables are single-conductor in sizes through 2000 kcmil or are flat or round multiple-conductor in sizes through 4/0 AWG copper, 300 kcmil aluminum or copper-clad aluminum jacketed and through 2000 kcmil coverless. Type USE and USE-2 cables are not required to comply with a cable flame test. Jacketed multiple-conductor Type USE and USE-2 cables have 1 – 5 insulated conductors of the same size with or without an uninsulated grounded conductor that, in some cases, is smaller than the insulated conductors. It is appropriate to include one insulated equipment-grounding conductor that is, in some cases, smaller than the circuit conductors in a cable with no uninsulated

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conductor. Coverless multiple-conductor Type USE and USE-2 cables have two or more (no limit) insulated conductors of the same size with or without a grounded conductor that bare (in round or flat cable) or insulated (in round cable) and, in some cases, is smaller than the other conductors. Coverless multiple-conductor Type USE and USE-2 cables with a bare conductor are tag marked to restrict the cable to direct burial (no covering to protect the bare conductor during and after duct and pole installations). Single-conductor Type USE and USE-2 cables that are not larger than 4/0 AWG copper, 300 kcmil aluminum or copper-clad aluminum and multiple-conductor jacketed and coverless Type USE and USE-2 cables without an uninsulated or bare conductor are for use as Type USE or USE-2 and also are for use underground as Type UF cable would be used however are not marked "UF". All single-conductor Type USE and USE-2 cables and the following multiple-conductor Type USE and USE-2 cables are for direct-burial and underground-duct service-entrance uses and are eligible to be terminated on a utility pole where each conductor and any overall jacket are exposed to the weather and not subject to physical damage:

a) Jacketed multiple-conductor Type USE and USE-2 cables with or without an uninsulated conductor.

b) Coverless multiple-conductor Type USE and USE-2 cables without a bare conductor.

1.8 Submersible-pump cable (four varieties are described in 19.1) is an assembly of single-conductor Type USE cables that are eligible to be individually surface marked "pump cable". The assembly is not tested for sunlight resistance however each of its conductors is so tested and complies. Submersible-pump cable is flat or round and is multiple-conductor in sizes through 4/0 AWG copper, 300 kcmil aluminum or copper-clad aluminum with all conductors insulated. It is appropriate for one conductor to be a grounding conductor that, in some cases, is smaller than the circuit conductors. All of the circuit conductors are of the same size. This cable has a tag marking stating that the cable is for use within well casings for wiring deep-well submersible water pumps. Each conductor in a coverless, cabled assembly is surface marked as Type USE, and each conductor in any other pump-cable assembly is eligible to also be so marked. Assemblies other than those that are coverless are surface marked "submersible pump cable". A coverless, cabled assembly without a grounding conductor is appropriate for use as Type USE and also appropriate for use underground as Type UF cable however it is not to be marked "UF". All other pump-cable assemblies are for use only as submersible-pump cable.

1.9 Type SE cable is a flat or round multiple-conductor cable in sizes through 4/0 AWG copper, 300 kcmil aluminum or copper-clad aluminum and has an overall nonmetallic covering. All of the insulated conductors are of the same size. This cable complies with a cable flame test.

1.10 These requirements do not cover metal-clad cables (Type MC) or medium-voltage cables (Type MV). Type MC cables (600 V and 2 kV) are covered in the Standard for Metal-Clad Cables, UL 1569. Type MV cables (5, 8, 15, 28, and 35 kV) are covered in the Standard for Medium-Voltage Power Cables, UL 1072.

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 requirements conveniently usable in countries employing the various metric systems (practical SI and customary). Equivalent – although not 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 where a requirement is applied in metric terms.

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2.2 Undated reference

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 Terms

3.1 Wherever the designation "UL 1581" is used in this wire standard, reference is to be made to the designated part(s) of the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

CONSTRUCTION

4 Materials

4.1 Each material used in a cable shall be compatible with all of the other materials used in the cable.

5 General

5.1 Service-entrance cable shall be designated as Type USE or USE-2 (jacketed, coverless, and submersible-pump cables – all for use below ground) or as Type SE (for use above ground) and shall comply in all respects with the applicable requirements for construction details, test performance, and markings.

5.2 The electrical insulation in each cable shall be of material(s) with one of the following ratings:

a) 90°C dry, 90°C wet;

b) 90°C dry, 75°C wet; or

c) 75°C dry, 75°C wet.

5.3 Each individual and overall jacket in Type USE and USE-2 cables and any insulation not protected by an individual jacket in Type USE and USE-2 cables shall be of material(s) resistant to fungi.

5.4 Material not known to be resistant to fungi is to be tested as described in the Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi, ASTM G 21). Based on an existing good field record, CP, CPE, XL, HDPE, NBR/PVC, and neoprene are appropriate for use without fungal testing.

CONDUCTORS

6 Metal

6.1 General

6.1.1 Only copper, copper-clad aluminum, or an aluminum alloy shall be used for the conductor(s) in a cable. All insulated conductors in a cable shall be of the same metal. In coverless Type USE and USE-2 cables with a bare conductor, the bare conductor shall be of metal-coated copper regardless of which of the three metals is used in the insulated conductors(s). In other multiple-conductor cables, any uninsulated conductor shall be of the same metal as the insulated conductors.

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6.2 Copper

6.2.1 A 14 or 12 AWG copper conductor in a Type SE cable shall be medium-hard or hard-drawn. Number 10 AWG and larger sizes of copper conductor in a Type SE cable and all sizes of copper conductor in Type USE and USE-2 cables shall be soft-annealed, medium-hard, or hard-drawn. Each solid copper conductor and each copper wire (strand) shall comply with the Standard Specification for Soft or Annealed Copper Wire, ASTM B 3, the Standard Specification for Medium-Hard-Drawn Copper Wire, ASTM B 2, or the Standard Specification for Hard-Drawn Copper Wire, ASTM B 1 as applicable.

6.3 Copper-clad aluminum

6.3.1 Copper-clad aluminum conductors shall comply with the Requirements for Copper-Clad Aluminum Conductors Used in Building Wire, Section 12 of UL 1581.

6.4 Aluminum

6.4.1 Solid aluminum conductors in sizes 12, 10 and 8 AWG shall comply with the requirements for aluminum-wire stock. The aluminum conductor(s) in single-conductor submersible-pump cable and in coverless multiple-conductor Type USE cable not marked with any additional conductor type designation on the surface, on the insulated conductors, or on the tag, reel, or carton shall comply with the requirements for 8000 series aluminum in Requirements for Aluminum Conductors of an 8000 Series Alloy, Section 10 of UL 1581, or shall be of a 1/2 – 3/4 hard 1350 series aluminum alloy that complies with the same tensile-strength requirements as a semi-annealed 8000 series alloy or a 1350-H19 (extra hard) aluminum alloy in accordance with the Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes, ASTM B 230/B 230M. All other aluminum conductors shall comply with the requirements for conductors of an 8000 series alloy in Section 10 of UL 1581. See 40.4.

7 Metal Coating

7.1 When the insulation adjacent to a copper or copper-clad aluminum conductor is of a material that corrodes unprotected copper in the test in Conductor Corrosion, Section 500 of UL 1581, and when a protective separator (see 11.1 and 11.2) is not provided, the solid conductor and each of the individual wires (strands) of a stranded conductor shall be separately covered with metal. The metal coating shall be one of the following:

a) A tin coating complying with the Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes, ASTM B 33.

b) A nickel coating complying with the Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes, ASTM B 355.

c) A silver coating complying with the Standard Specification for Silver-Coated Soft or Annealed Copper Wire, ASTM B 298.

d) Any other metal or alloy coating is to be evaluated.

7.2 The use of a metal coating, when not required for corrosion protection, is still appropriate for use on solid or individual wires (strands) or selected wires, such as the outer layer of wires of a stranded conductor (see 7.3 concerning the conductor resistance). The metal coating used shall comply with 7.1.

7.3 When metal-coated wires are used only as selected wires, such as the outer layer of wires of a stranded uncoated copper or copper-clad aluminum conductor, the direct current resistance of the resulting conductor shall not exceed the value tabulated in D-C Conductor Resistance, Section 30 of UL 1581 for an uncoated conductor of the same size and construction. See 10.1.

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7.4 An uninsulated copper or copper-clad aluminum conductor shall be metal-coated when it is assembled in contact with a neoprene jacket or (copper only) is used as the bare conductor in a coverless multiple-conductor Type USE or USE-2 cable. A stranded copper or copper-clad aluminum conductor that is required to be metal-coated shall have each wire (strand) metal-coated before the wires are assembled to form the conductor.

8 Conductor Diameter and Cross-Sectional Area

8.1 The nominal, maximum (1.01 x nominal), and minimum (0.98 x nominal) diameters of solid and stranded conductors are shown in Tables 20.1, 20.2, 20.3, 20.3.1, 20.4, and 20.6 of UL 1581. Conductor Diameter is to be measured using the method shown in Conductor Diameters, Section 200 of UL 1581.

8.2 Compressed unilay copper conductors that are smaller in diameter than the requirement (0.98 x nominal as indicated in Table 20.3) for compressed concentric lay conductors shall be marked the same as compact conductors and shall be marked in accordance with 43.1.

8.3 The nominal cross-sectional area of a conductor is indicated in Table 20.1 of UL 1581 (not a requirement).

9 Joints

9.1 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 change 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. A joint in a stranded conductor shall be made by separately joining each individual wire. A joint shall be made only before any coverings are applied to an insulated conductor and before a conductor is assembled into a cable. The insulation applied to such joints shall be equivalent to that removed and shall comply with the requirements in this Standard. A joint in a compact- or compressed-stranded conductor shall be made before compacting or compressing.

10 Resistance

10.1 The direct-current resistance of any length of conductor in ohms per thousand conductor feet or in ohms per conductor kilometer shall not be higher than the maximum (nominal x 1.02) resistance indicated in the applicable table in D-C Conductor Resistance, Section 30 of UL 1581 at 20°C (68°F) or at 25°C (77° F) when measured as described in D-C Conductor Resistance, Section 220 of UL 1581. The d-c resistance of each insulated conductor in a multiple-conductor cable in which the insulated conductors are cabled shall not exceed the tabulated value first multiplied by 1.02 and then rounded off to the same number of decimal places as the tabulated value. See 7.3.

11 Separator

11.1 Thermoset insulation shall be kept, by the manufacturing process or a separator, from penetrating between the wires (strands) of a stranded copper, copper-clad aluminum, or aluminum conductor (see Insulation Fall-In Test, Section 520 of UL 1581). A separator is not required between the conductor and the thermoset or thermoplastic insulation on a solid or stranded conductor. Where used, a separator shall be electrically non-conductive (an insulating grade is not required), inherently resistant to moisture, and shall not be counted as part of the required insulation.

11.2 A separator used between a conductor and insulation shall be colored or shall be opaque to make the separator clearly distinguishable from the conductor once the insulation is removed. The color shall be other than copper, silver, green, or green and yellow and shall be solid, striped, or in some other pattern.

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12 Sizes of Insulated Conductors

12.1 The grounding conductor (insulated), where used, in 8 – 4/0 AWG copper submersible-pump cable and in 6 AWG – 300 kcmil aluminum or copper-clad aluminum submersible-pump cable shall be the same as or smaller in size (see Table 19.1) than the circuit conductors (also insulated) however, in other multiple-conductor cables, the insulated conductors shall be of the same size.

12.2 An insulated copper conductor shall not be smaller in size than 14 AWG. An insulated aluminum or copper-clad aluminum conductor shall not be smaller in size than 12 AWG.

12.3 Single-conductor Type USE and USE-2 cables and the insulated conductors in multiple-conductor coverless Type USE and USE-2 cables shall not be larger in size than 2000 kcmil. The insulated conductor(s) in other multiple-conductor Type USE and USE-2 cables (jacketed cable or submersible-pump cable) and the insulated conductors in a Type SE cable shall not be larger than 4/0 AWG copper, 300 kcmil aluminum or copper-clad aluminum.

13 Stranding

13.1 Except as noted in this paragraph, a 6 AWG or larger size of insulated conductor shall be stranded in compliance with the Standard for Thermoset-Insulated Wires and Cables, UL 44, or in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, as applicable. 12 – 2 AWG conductors in the submersible-pump cables described in Details, Section 19, shall be solid or stranded. A solid conductor for use as the insulated conductor of a single-conductor cable or a 2-conductor cable having a stranded bare or uninsulated conductor applied helically over the insulated conductor shall not be larger than 2 AWG. A 6 AWG or larger size of bare or uninsulated conductor shall be stranded. No strand of an uninsulated copper conductor shall be smaller than 26 AWG (15.9 mils or 0.404 mm in diameter). No strand of an uninsulated aluminum or copper-clad aluminum conductor shall be smaller than 22 AWG (25.3 mils or 0.643 mm in diameter).

13.2 Compact stranding is appropriate for use with 8 AWG – 1000 kcmil aluminum conductors and with 2 – 4/0 AWG copper conductors. A compact-stranded conductor shall not be segmented. The length of lay of the strands in the outer layer of a round compact-stranded assembly shall be 8 – 16 times the overall diameter of that layer for a 1 AWG – 1000 kcmil conductor and shall be 8.0 – 17.5 times the overall diameter of that layer for a 8 – 2 AWG conductor. The direction of lay of the outer layer of a round compact-stranded conductor shall be left-hand (left-hand unidirectional or concentric-lay-stranded with the outer layer left-handed).

INSULATION AND INDIVIDUAL JACKET

14 Details

14.1 The insulation in Type USE and USE-2 cables shall be thermoset, except for the HDPE portion of HDPE-over-XL insulation in some single-conductor Type USE cable. See 14.3 regarding materials. The insulation and jacket in single-conductor Type USE and USE-2 cables shall comply with Table 14.1 and Table 14.2 (see 14.3 regarding materials). Each insulated conductor in the submersible-pump cables that are described in Section 19, and in the coverless multiple-conductor Type USE and USE-2 cables that are described in Section 18, shall be a single-conductor Type USE or USE-2 cable. Except for the horizontal flame test in some cases (see 40.1), and the sunlight-resistance tests required in 30.1 and 30.3.1, the insulated conductors in a Type SE cable shall be Type THHN, Type THWN, or Type THWN-2 as described in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, or Type XHHW, Type XHHW-2, Type RHW, Type RHW-2, Type RHH OR RHW, or Type RHH OR RHW-2 as described in the Standard for Thermoset-Insulated Wires and Cables, UL 44; the insulated conductors in a jacketed multiple-conductor Type USE cable shall be Type XHHW, Type XHHW-2, Type RHW, Type RHW-2, Type RHH OR RHW, or Type RHH OR RHW-2 as described in the Standard for Thermoset-Insulated Wires and Cables, UL 44.

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and the insulated conductors in a jacketed multiple-conductor Type USE-2 cable shall be Type XHHW-2, Type RHW-2, or Type RHH OR RHW-2 as described in the Standard for Thermoset-Insulated Wires and Cables, UL 44. "USE" shall not be surface marked on conductors for Type SE cable.

14.2 Measurements of insulation thickness are to be made as described in Thicknesses of Insulation on Thermoplastic- and Thermoset-Insulated Wires and Cables, Section 240 of UL 1581.

14.3 Either of the following materials intended for use by the manufacturer as an insulation or a jacket shall be evaluated for the requested temperature rating as described in Long-Term Aging, Section 481 of UL 1581:

a) Material generically different from any insulation or jacket material that is referenced in 14.1, 17.2.1.1, or 19.1 for the construction (new material).

b) Material that is referenced in 14.1, 17.2.1.1, or 19.1 yet does not comply with the short-term tests applicable to the material.

The temperature rating of materials (a) and (b) shall be as required for the specific service-entrance cable type. The thicknesses of insulation and/or jacket using materials (a) and/or (b) shall be as required for the specific type. Investigation of the electrical, mechanical, and physical characteristics of the cable using material (a) and/or (b) shall show the material(s) to be comparable in performance to the insulation or jacket materials referenced in 14.1, 17.2.1.1, or 19.1. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock, insulation resistance, and dielectric voltage-withstand.

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