UL 854

STANDARD FOR SAFETY

Service-Entrance Cables

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 July 2, 2024 includes the following changes:

– Gasoline and Oil Resistant Markings, Revised 42.1 and 42.2 to Add PRI, PRII and GRI, GRII.

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 May 10, 2024.

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UL 854

Standard for Service-Entrance Cables

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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

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.

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.

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.

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.

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;

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.

Table 14.1
Constructions of single-conductor Type USE cables
NOTE: FOR DETAILS OF BLANK OR INCOMPLETE BOXES REFER TO THE CORRESPONDING BOX ON THE PAGE PRECEDING IT.

Insulation			Jacket			Cable surface marking (see Section 40)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	Physical properties	Thicknesses	Material	Physical properties	Thicknesses		
75°C wet or dry XL	113°C aging in Table 50.231 of UL 1581	Table 14.3 (note[b] reduced thicknesses are applicable)	No jacket			"USE"	600 V RHW insulated with unjacketed XL or EPCV. Horizontal flame test not required (see last sentence of 40.1).
		Table 14.3 (note[b] reduced thicknesses are not applicable)	No jacket			"USE OR RHW"	600 V RHW insulated with unjacketed XL or EPCV. Horizontal flame test is required.
		Table 14.3 (note[b] reduced thicknesses are not applicable)	75°C		Table 14.5	"USE"	600 V RHW insulated with jacketed XL or EPCV. Horizontal flame test not required (see last sentence of 40.1). Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
			CP	Table 50.1 of UL 1581			
			Thermoset CPE	Table 50.30 of UL 1581			
			NBR/PVC	Table 50.100 of UL 1581			
			Neoprene	Table 50.100 of UL 1581			
			XL	Table 50.229 of UL 1581			
						"USE OR RHW"	600 V RHW insulated with jacketed XL or EPCV. Horizontal flame test is required. Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
75°C wet or dry EPCV	Table 50.62 of UL 1581 (121°C aging for all applications)	Table 14.3 (note[b] reduced thicknesses are not applicable)	75°C		Table 14.5	"USE"	600 V RHW insulated with jacketed XL or EPCV Horizontal flame test not required (see last sentence of 40.1). Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.

Table 14.1 Continued on Next Page

Table 14.1 Continued

Insulation			Jacket			Cable surface marking (see Section 40)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	Physical properties	Thicknesses	Material	Physical properties	Thicknesses		
			CP	Table 50.1 of UL 1581		"USE OR RHW"	600 V RHW insulated with jacketed XL or EPCV. Horizontal flame test not required. Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
			Thermoset CPE	Table 50.30 of UL 1581			
			NBR/PVC	Table 50.100 of UL 1581			
			Neoprene	Table 50.100 of UL 1581			
			XL	Table 50.229 of UL 1581			
		Table 14.3 (note[b] reduced thicknesses are not applicable)	No jacket			"USE OR RHW"	600 V RHW insulated with unjacketed XL or EPCV. Horizontal flame test is required.
90°C dry, 75°C wet		Table 14.3 (note[b] reduced thicknesses are not applicable)	No jacket			"USE OR RHW OR RHH"	600 V RHH and RHW insulated with unjacketed XL or EPCV. Horizontal flame test is required.
XL	121°C aging in Table 50.231 of UL 1581						
EPCV	Table 50.62 of UL 1581 (121°C aging for all applications)						
90°C dry, 75°C wet		Table 14.3 (note[b] reduced thicknesses are not applicable)	90°C		Table 14.5	"USE OR RHW OR RHH"	600 V RHH and RHW insulated with jacketed XL or EPCV. Horizontal flame test is required. Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
XL	121°C aging in Table 50.231 of UL 1581		CP	121°C aging in Table 50.1 of UL 1581			
EPCV	Table 50.62 of UL 1581 (121°C aging for all applications)		Thermoset CPE	Table 50.29 of UL 1581			
			NBR/PVC	Table 50.99 of UL 1581			
			Neoprene	Table 50.99 of UL 1581			
			XL	Table 50.228 of UL 1581			
90°C dry, 75°C wet CP or CPE	121°C aging in Table 50.1 of UL 1581	Table 14.3 (note[b] reduced thicknesses are not applicable)	No Jacket			"USE"	600 V RHH and RHW insulated with unjacketed CP or CPE.

Table 14.1 Continued on Next Page

Table 14.1 Continued

Insulation			Jacket			Cable surface marking (see Section 40)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	Physical properties	Thicknesses	Material	Physical properties	Thicknesses		
							Horizontal flame test not required (see last sentence of 40.1).
						"USE OR RHW OR RHH"	600 V RHH and RHW insulated with unjacketed CP or CPE. Horizontal flame test is required.
75°C wet or dry: thermoplastic HDPE over XL	HDPE[a] : Table 50.135 of UL 1581 (113°C aging) XL[a] : 113°C aging in Table 50.231 of UL 1581	Table 14.3 (note[b] reduced thicknesses are applicable)	No jacket			"USE"	600 V RHW insulated with unjacketed XL. Horizontal flame test not required (see last sentence of 40.1).
90°C dry, 75° wet: CP, CPE, EPCV, or XL over EP, XL or EPCV	CP[b]: 121° C aging in Table 50.1 of UL 1581 CPE[b]: Table 50.34 of UL 1581 (121°C aging) EP[b]: Table 11 of UL 44 same as Type RHH EPCV[b]: Table 50.62 of UL 1581 (121° C aging for all applications) XL[b]: 113°C aging in Table 50.231 of dUL 1581	Table 14.4	No jacket			"USE"	600 V RHH and RHW insulated wtih unjacketed CP, CPE, EPCV, or XL over EP, XL, or EPCV. Horizontal flame test not required (see last sentence of 40.1).
						"USE OR RHW OR RHH"	600 V RHH and RHW insulated wtih unjacketed CP, CPE, EPCV, or XL over EP, XL, or EPCV. Horizontal flame test is required
75°C wet or dry		Table 14.3 (note[b] reduced thicknesses are not applicable)	75°C		Table 14.5	"USE "	600 V RHH and RHW insulated with jacketed SBR/IIR/NR or EP Horizontal flame test not required (see last sentence of 40.1).
			CP	Table 50.1 of UL 1581			
SBR/IIR/NR	Agings for 75°C materials in Table 50.189 of UL 1581		Thermoset CPE	Table 50.30 of UL 1581			Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
			NBR/PVC	Table 50.100 of UL 1581			
EP	Table 50.42 of UL 1581 (121°C aging for all applications)		Neoprene	Table 50.29 of UL 1581		"USE OR RHW"	600 V RHW insulated with jacketed SBR/IIR/NR. Horizontal flame test is required. Tests made without jacket: insulation, resistance, capacitance, relative permittivity, and stability factor.
			XL	Table 50.229 of UL 1581			

Table 14.1 Continued on Next Page

Table 14.1 Continued

Insulation			Jacket			Cable surface marking (see Section 40)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	**Physical properties**	**Thicknesses**	**Material**	**Physical properties**	**Thicknesses**		
90°C dry, 75°C wet		Table 14.3 (note[b] reduced thicknesses are not applicable)	90°C		Table 14.5	"USE OR RHW OR RHH"	600 V RHH and RHW insulated with jacketed SBR/IIR/NR or EP.
SBR/IIR/NR	Agings for 90°C materials in Table 50.189 UL 1581		CP	Table 50.1 of UL 1581			
EP	Table 50.42 of UL 1581 (121°C aging for all applications)		Thermoset CPE	Table 50.29 of UL 1581			Horizontal flame test is required. Tests made without jacket: insulation, resistance, capacitance, permittivity, and stability factor.
			NBR/PVC	Table 50.99 of UL 1581			
			Neoprene	Table 50.99 of UL 1581			
			XL	Table 50.228 of UL 1581			

[a] For the 8 AWG and smaller sizes, HDPE over XL may be tested as a composition tube of the two layers at 2.0 ±0.2 in/min (50 ±5 mm/min). For the 6 AWG and larger sizes, the layers are to be tested separately, with the HDPE layer at 2.0 ±0.2 in/min (50 ±5 mm/min) and the XL layer at 20 ±1 in/min (500 ±25 mm/min).

[b] Each layer is to be tested separately.

Table 14.2
Acceptable constructions of single-conductor Type USE-2 cable

Insulation			Jacket			Cable surface marking (see Section 39)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	**Physical properties**	**Thicknesses**	**Material**	**Physical properties**	**Thicknesses**		
90°C wet or dry		Table 14.3 (note c reduced thicknesses not acceptable)	No Jacket			"USE-2 OR RHW-2" See Table 14.1	600 V RHW-2 insulated with unjacketed XL or EPCV. Horizontal flame test is required.
XL	121°C aging in Table 50.231 of UL 1581						
EPCV	Table 50.62 of UL 1581 (121°C aging for all applications)						
90°C wet or dry		Table 14.3 (note c reduced thicknesses not acceptable)	90°C		Table 14.5	"USE-2 OR RHW-2"	600 V RHW-2 insulated with jacketed XL or EPCV. Horizontal flame test is required. Tests made without jacket: insulation resistance, capacitance, relative permittivity, and stability factor.
			CP	121°C aging in Table 50.1 of UL 1581			
XL	121°C aging in Table 50.231 of UL 1581		Thermoset CPE	Table 50.29 of UL 1581			
			NBR/PVC	Table 50.99 of UL 1581			
EPCV	Table 50.62 of UL 1581 (121°C aging for all applications)		Neoprene	Table 50.99 of UL 1581			
			XL	Table 50.228 of UL 1581			
90°C wet or dry CP	121°C aging in Table 50.1 of UL 1581	Table 14.3	No Jacket			"USE-2"	600 V RHW-2 insulated with unjacketed CP. Horizontal flame test not required.
						"USE-2 or RHW-2"	600 V RHW-2 insulated with unjacketed CP. Horizontal flame test is required.
90°C wet or dry: CP, CPE, EPCV,	CP[a] : 121° caging in Table 50.1 of UL 1581 CPE[b].					"USE-2"	600 V RHW-2 insulated with unjacketed CP, CPE, EPCV, or XL over EP, XL or EPCV.

Table 14.2 Continued on Next Page

Table 14.2 Continued

Insulation			Jacket			Cable surface marking (see Section 39)	Applicable requirements in UL 44 (includes spark or tank testing of all production)
Material	Physical properties	Thicknesses	Material	Physical properties	Thicknesses		
or XL over EP, XL, or EPCV	Table 50.34 of UL 1581 (121°C aging) EP[a] : Table 11 of UL 1581 (same as Type RHH) EPCV[a] : Table 50.62 of UL 1581 (121°C aging for all applications) XL[b]: 113°C aging in Table 50.231 of UL 1581	Table 14.4	No jacket				Horizontal flame test not required (see last sentence of 39.1).
						"USE-2 or RHW-2"	600 V RHW-2 insulated with unjacketed CP, CPE, EPCV, or XL over EP, XL or EPCV. Horizontal flame test is required.
90°C wet or dry		Table 14.3 (note [c] reduced thicknesses are not applicable)	90°C		Table 14.5	"USE-2 OR RHW-2"	600 V RHW-2 insulated with jacketed SBR/IIR/NR or EP. Horizontal flame test is required. Tests made without jacket: insulation resistance, capacitance, relative permittivity, and stability factor.
			CP	Table 50.1 of UL 1581			
SBR/IIR/NR	Agings for 90°C materials in Table 50.189 UL 1581		Thermoset CPE	Table 50.29 of UL 1581			
EP	Table 50.42 of UL 1581 (121°C aging for all applications)		NBR/PVC	Table 50.99 of UL 1581			
			Neoprene	Table 50.99 of UL 1581			
			XL	Table 50.228 of UL 1581			

[a] Each layer is to be tested separately.

Table 14.3
Thicknesses of insulation of XL, of EPCV, of EP, of SBR/IIR/NRm of CP, of CPE, or of HDPE[a] over XL[a] on single-conductor Type USE-2 and USE cables

Size(s) conductor		Mils		(mm)	
Copper	Aluminum or copper-clad aluminum	Nominal thickness of insulation[d]	Minimum thickness at any point of insulation	Nominal thickness of insulation[d]	Minimum thickness at any point of insulation
14, 10 AWG	12, 10 AWG	45	40	(1.14)	(1.02)
9 – 2	8 – 2	60	54	(1.52)	(1.37)
1 – 4/0	1 – 4/0	80	72	(2.03)	(1.83)
213 – 500 kcmil	213 – 500 kcmil	95 (80)[b, c]	86 (72)[b, c]	[2.41 (2.03)][b, c]	[2.18 (1.83)][b, c]
501 – 1000	501 – 1000	110	99	(2.79)	(2.51)
1001 – 2000	1001 – 2000	125	112	(3.18)	(2.84)

[a] The thicknesses of the individual layers are not specified.

[b] The reduced thicknesses shown in parentheses shall be used only for XL or for HDPE over XL on the 213 – 500 kcmil sizes of Type USE cable that are not marked "USE OR RHW" or "USE OR RHW OR RHH" (the cable is marked simply "USE" – the cable contains EC-1350 grade aluminum alloy conductors; see 41.4) when the results of the tests described in Sections 21 – 25 show that these sizes of cable made with the reduced thicknesses of insulation have mechanical-abuse characteristics that are comparable to the characteristics of the same cable made with the thicknesses of insulation shown without the parentheses. The 213 – 500 kcmil sizes of cable made with reduced thicknesses of XL insulation shall have the insulation applied in one or two layers. The thicknesses of the individual layers are not specified.

[c] The reduced thicknesses shown in parentheses shall be used only for XL on the 213 – 500 kcmil sizes of cable that are not marked "USE-2 OR RHW-2" or "USE-2 OR RHW-2 OR RHH" (the cable is marked simply "USE-2" – the cable contains ED-1350 grade aluminum alloy conductors; see 41.4) when the results of the tests described in Sections 21 – 25 show that these sizes of cable made with the reduced thicknesses of insulation have mechanical-abuse characteristics that are comparable to the characteristics of the same cable made with the thicknesses of insulation shown without the parentheses. The 213 – 500 kcmil sizes of cable made with reduced thicknesses of XL insulation shall have the insulation applied in one or two layers. The thicknesses of the individual layers are not specified.

[d] The nominal insulation thickness is not a requirement, but for simplicity of identifying cable products.

Table 14.4
Thicknesses of insulation of CP, CPE, EPCV, or XL over EP, XL, or EPCV on single-conductor Type USE-2 and USE cables with no jacket over the insulation

Sizes(s) of conductor		Mils						(mm)					
		Inner layer EP, XL or EPCV			Outer layer CP, CPE, EPCV, or XL			Inner layer EP, XL or EPCV			Outer Layer CP, CPE, EPCV, or XL		
Copper	Aluminum or copper-clad aluminum	Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]	
			I	II		I	II		I	II		I	II
AWG	AWG												
14 – 10	12 – 10	30	27	28	15	14	12	(0.76)	(0.69)	(0.71)	(0.38)	(0.36)	(0.30)
9 – 8	9 – 8	45	40	42	15	14	12	1.14	(1.02)	(1.07)	(0.38)	(0.36)	(0.30)
7 – 2	7 – 2	45	40	44	30	27	24	1.14	(1.02)	(1.12)	(0.76)	(0.69)	(0.61)
1 – 4/0	1 – 4/0	55	50	54	45	40	36	1.40	(1.27)	(1.37)	(1.14)	(1.02)	(0.91)
kcmil	kcmil												

Table 14.4 Continued on Next Page

Table 14.4 Continued

Sizes(s) of conductor		Mils						(mm)					
		Inner layer EP, XL or EPCV			Outer layer CP, CPE, EPCV, or XL			Inner layer EP, XL or EPCV			Outer Layer CP, CPE, EPCV, or XL		
Copper	Aluminum or copper-clad aluminum	Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]		Nominal thickness of insulation[b]	Minimum thickness at any point of insulation[a]	
			I	II		I	II		I	II		I	II
213 – 500	213 – 500	65	58	65	65	58	52	1.65	(1.47)	(1.65)	(1.65)	(1.47)	(1.32)
501 – 1000	501 – 1000	80	72	78	65	58	52	2.03	(1.83)	(1.98)	(1.65)	(1.47)	(1.32)

[a] The minimum thickness at any point shall not be less than indicated in column I or II under "Inner Layer" provided that the minimum thickness at any point is not less than indicated in the corresponding column I or II under "Outer Layer". The thickness in column II under "Inner Layer" plus the thickness in column II under "Outer Layer" equals 90 percent of the sum of the average thicknesses indicated under "Inner Layer" and "Outer Layer".

[b] The nominal insulation thickness is not a requirement, but for simplicity of identifying cable products.

Table 14.5
Thicknesses of jacket on single-conductor Type USE-2 and USE cables with insulation that is required in Table 14.1 to have thicknesses per Table 14.3

Size(s) of Conductor		inch		(mm)	
Copper	Aluminum or copper-clad aluminum	Minimum average thickness of jacket[a]	Minimum thickness at any point of jacket[a]	Minimum thickness at any point of jacket[a]	Minimum thickness at any point of jacket[a]
14 – 2 AWG	12 – 2 AWG	30	25	(0.76)	(0.64)
1 – 4/0	1 – 4/0	45	35	(1.14)	(0.89)
213 – 1000 kcmil	213 – 1000 kcmil	65	50	(1.65)	(1.27)
1001 – 2000	1001 – 2000	95	75	(2.41)	(1.90)

[a] Measurements are to be made as described in 17.2.2.2.

ASSEMBLY OF JACKETED MULTIPLE-CONDUCTOR TYPE USE AND USE-2 CABLES AND OF TYPE SE CABLE

15 Conductors

15.1 In jacketed multiple-conductor Type USE and USE-2 cables and in a Type SE cable, the insulated conductors and any uninsulated conductor shall be assembled in size and number as indicated in Table 15.1. It is appropriate for an uninsulated conductor to be laid straight in a flat cable, or to be cabled in one or several sections in a round cable, where the requirements of at least the flexing test in 21.1 and the overload test in 26.1 and 26.1 for Type USE and USE-2 cables or the overload test in 27.1 and 27.2 for Type SE cable are complied with. Otherwise, an uninsulated conductor shall be evenly distributed helically (concentric) over the insulated conductor or conductors with a length of lay that complies with 15.4. An insulated conductor shall not be smaller in size than indicated in Table 15.2 (cable with copper conductors) or Table 15.3 (cable with aluminum or copper-clad aluminum conductors). It is appropriate for Type USE and USE-2 cables that are without an uninsulated conductor to contain one fully insulated grounding conductor that is of the same construction as the circuit conductors. The grounding conductor shall be of a size that is not smaller than indicated in Table 19.1 and shall be identified as described in 19.2.

15.2 In a round cable in which there is more than one insulated conductor, the insulated conductors shall be cabled with a length of lay (see 15.3) that is uniform and is not longer than indicated in Table 15.4. The length of lay of a cabled uninsulated conductor shall be the same as the length of lay of the insulated

conductors. In a round Type SE cable, it is appropriate for the direction of lay to change at uniform or varied intervals throughout the length of the cable. In a cable in which the lay is reversed:

a) Each area in which the lay is right- or left-hand for not less than 5 complete twists (full 360° cycles) shall have the insulated conductors cabled with a length of lay that is not greater than indicated in Table 15.4, and

b) The length of each lay-transition zone (oscillated section) between these areas of right- and left-hand lay shall not exceed 1.8 times the maximum length of lay indicated in Table 15.4.

15.3 The length of lay of an element of a helix is the pitch of that element – that is, the axial length of one turn of the element.

15.4 The length of lay of the wires of a concentrically distributed (evenly spaced), helically applied, uninsulated conductor shall not be more than 10 times the diameter over the concentric wires in a round cable, and shall not be more than 35 times the length of the minor axis over the concentric wires in a flat Type SE cable. The length of lay of the concentric wires shall be uniform throughout the length of the cable or the direction of lay can change at uniform or varied intervals throughout the length of the cable. In a cable in which the lay of the concentric wires is reversed:

a) Each area in which the lay is right- or left-hand for not less than 5 complete twists (full 360° cycles) shall have the wires applied with a length of lay that is not greater than the limit shown above.

b) The length of each lay-transition zone (oscillated section) between these areas of right- and left-hand lay shall not exceed 1.8 times the length of lay limit shown above.

Table 15.1
Assembly of conductors in jacketed multiple-conductor Type USE-2 and USE cables and in Type SE cables

Number of conductors		Sizes of insulated conductor(s)			
		In flat cable		In round cable	
Insulated	Uninsulated	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
1	1	Cable is round.		14 – 4/0 AWG	12 AWG – 300 kcmil
2	0 or 1	14 – 4/0 AWG	12 AWG – 300 kcmil	14 – 4/0	12 AWG – 300 kcmil
3, 4, or 5	0 or 1	Cable is round		14 – 4/0	12 – AWG 300 kcmil

Table 15.2
Smallest size of uninsulated conductor in cable with copper conductors

Number of insulated copper conductors	Size of insulated copper conductors	Uninsulated conductor of copper
One	All	Same size as the insulated conductor
Two or more	14 – 8 AWG	Same size as the insulated conductors
Two or more	Larger than 8 AWG however not larger than 4/0 AWG	Two AWG sizes smaller than the insulated conductors

Table 15.3
Smallest size of uninsulated conductor in cable with aluminum or copper-clad aluminum conductors

Number of insulated aluminum or copper-clad aluminum conductors	Size of insulated aluminum or copper-clad aluminum conductors	Uninsulated conductor of aluminum or copper-clad aluminum
One	All	Same size as the insulated conductors
Two or more	12 – 6 AWG	Same size as the insulated conductors
Two or more	Larger than 6 AWG however not larger than 300 kcmil	Two sizes smaller than the insulated conductors

Table 15.4
Cabling of insulated conductors in jacketed, round, multiple-conductor Type USE-2 and USE cables and in Type SE cable

Number of insulated conductors in cable	Maximum length of lay of cabled conductors
2	30 times the calculated diameter over one finished insulated conductor
3	35 times the calculated diameter over one finished insulated conductor
4	40 times the calculated diameter over one finished insulated conductor
5	15 times the calculated diameter over the assembled, finished insulated conductors (a concentric uninsulated conductor and/or a separator tape over the assembled insulated conductors are excluded)

16 Fillers

16.1 Fillers shall be provided in a cable that has an overall covering and contains two or more insulated conductors where the fillers are needed to make the cable firm at all points. Fillers shall be provided in a Type SE cable where they are needed to keep the shape of the cable from reducing the ability of the cable to comply with the pulling-through-joists test described in Low-Temperature Pulling-Through-Joists Test, Section 32. Fillers are not required in a flat cable with a concentric uninsulated conductor. Fillers shall be provided in a flat cable without an uninsulated conductor or with an uninsulated conductor that is entirely in one location (not sectioned or concentric) and in a round cable where they are needed to keep the shape of these cables:

a) From making the surface printing on the cable illegible,

b) From reducing the ability of the cable to resist pulling out of any connector intended for the cable (see test described in note a to Table 17.1), and

c) From affecting the seal of a watertight entrance fitting [see the wet-locations test (rain test) described in Section 39, of the Standard for Fittings for Cable and Conduit, UL 514B].

Fillers in a jacketed cable shall be integral with or separate from the overall jacket. Where fillers are integral with the overall jacket, they and the jacket shall be readily separable from the underlying cable assembly. Fibrous filler materials shall be inherently resistant to moisture or shall be treated to make them moisture resistant.

17 Overall Covering

17.1 General

17.1.1 Type SE cable and all multiple-conductor Type USE and USE-2 cables other than submersible-pump cables (see Section 19) and the coverless assemblies of single-conductor Type USE and USE-2

cables (see Section 18) shall be enclosed in an overall nonmetallic covering. In all cases, the finished cable shall have an outer surface that complies with the sunlight-resistance requirements (720 h for cables marked for sunlight-resistance use and for sunlight-resistance use in cable trays and 300 h or equivalent for all others) in the Sunlight-Resistance Test, 30.2. The covering shall be applied directly over the flat or round assembly of insulated conductors, any uninsulated conductor, and any fillers; shall completely cover and conform closely to the surface of the underlying assembly; and shall be snug-fitting but readily separable from the underlying assembly. The outer surface of the finished overall covering shall be firm and smooth and except for impressions of the underlying assembly shall not show depressions caused by unfilled spaces beneath the overall covering [see 16.1 (a) – (c)]. Neither an overall jacket nor a PVC finish shall have any defects (bubbles, open spots, rips, tears, cuts, or foreign material) that are visible with normal or corrected vision without magnification. An overall jacket and a PVC finish shall be well centered over the underlying assembly.

17.1.2 The covering on Type USE and USE-2 cables shall be an extruded jacket complying with 17.2. The covering on Type SE cable shall be a tape-and-finish construction complying with 17.3.

17.2 Jacket

17.2.1 Material

17.2.1.1 The overall jacket on Type USE and USE-2 cables shall be of one of the thermoset materials indicated in Table 17.1 (see 14.3 for the long-term evaluation of a jacket material not named in Table 17.1 or not complying with the specified short-term tests). Specimens prepared from samples of the overall jacket taken from the finished cable shall comply with the physical properties limits specified in the table in Specific Materials, Section 50 of UL 1581, to which reference is made in Table 17.1. The methods of preparation of samples, of selection and conditioning of specimens, and of making the measurements and calculations for recovery, ultimate elongation, and tensile strength shall be as indicated under the heading "Physical Properties Tests of Insulation and Jacket", Sections 400 – 480 in UL 1581.

17.2.1.2 Oil is specified in several of the physical properties tables in UL 1581 as an immersion medium for conditioning some specimens. In Service-Entrance Cables, UL 854, the oil immersion is for the purpose of generic material identification, not to establish a particular compound as being oil-resistant.

Table 17.1
Material[a] of extruded, thermoset, overall jacket on jacketed multiple-conductor Type USE cable

Jacketed Material[a]	Applicable table of physical properties in UL 1581	
	Cable with 90°C (194°F) insulated conductors(s)	Cable with 75°C (167°F) insulated conductor(s) or unmarked 90°C (194°F) insulated conductor(s)
CP	50.1	50.1
Thermoset CPE	50.29	50.30
NBR/PVC	50.99	50.100
Neoprene	50.99	50.100
XL	50.228	50.229

[a] An overall jacket of a thermoset material other than one of those mentioned in the first column of this table when used, shall be applicable for the use. A pullout test is to be part of the evaluation. In the test, an outlet bushing is to be secured to the finished cable as intended using the tightening torque indicated below and a 50 lbf or 22.7 kgf is to be exerted for 5 min along the longitudinal axis of the bushing to tend to pull the cable out of the bushing. The cable shall not move more than 1/8 in (3 mm) in the bushing.

Table 17.1 Continued on Next Page

Table 17.1 Continued

Trade size of fitting in inches	Tightening torque		
	lbf-in	N·m	kgf-m
3/4	500	56.5	5.76
1	700	79.1	8.06
1-1/4	1000	113	11.5
1-1/2	1200	136	13.8
2 and larger	1600	181	18.4

17.2.2 Thicknesses

17.2.2.1 The average and minimum-at-any-point thicknesses of the overall jacket on jacketed multiple-conductor Type USE and USE-2 cables shall not be less than indicated in Table 17.2. The method in 17.2.2.2 also applies to the determination of the thicknesses of the jacket on jacketed single-conductor Type USE and USE-2 cables, as indicated in note a to Table 14.5.

17.2.2.2 Specimens are to be measured as described in Thicknesses of Jacket on Thermoplastic- and Thermoset-Insulated Wires and Cables, Section 260 of UL 1581.

17.3 Tape and finish

17.3.1 Tape

17.3.1.1 The tape portion of an overall tape-and-finish covering on a Type SE cable shall be constructed as described in either (a) or (b) below:

a) A single layer of tape (see 17.3.1.2 for the method of thickness measurement). The tape shall be of any convenient width and shall be applied in either of two ways: helically without creases or folds and with an overlap of at least 1/4 in (6 mm), or longitudinally with an overlap of at least 1/4 in (6 mm) and with a glass-fiber binder having a length of lay not exceeding 3-1/2 in (89 mm). The tape shall consist of reinforced polyester, cellulose acetate, or other film tape that is at least 0.0035 in (0.09 mm) in overall thickness. The tape is to be reinforced on one face by threads of glass fiber. The glass threads either are to be bonded to the tape without a covering over the threads or are to be bound to the tape by a film of polyester or vinyl or other material applied over the threads. The film is to be at least 0.00048 in (0.012 mm) thick. The glass threads either are to be laid longitudinally (unidirectional) in an open pattern or are to be applied longitudinally and across the tape (bidirectional) in an open pattern or weave.

b) One or two layers of a neoprene tape that consists of an unvulcanized neoprene coating at least 0.006 in (0.15 mm) thick (see 17.3.1.2 for the method of thickness measurement) applied to reinforcement consisting of an open, bidirectional pattern or weave of threads of glass fiber. The tape shall be of any convenient width and shall be applied helically without creases or folds. Where one serving is used, the edges of the tape shall be overlapped at least 1/4 in (6 mm). Where two servings are used and they are applied in opposite directions, the edges of the tape in each serving shall be overlapped at least 1/4 in (6 mm). Where two servings are used and they are applied in the same direction,

1) The edges of the tape in each serving shall be abutted or shall be overlapped at least 1/4 in (6 mm), and

2) The abutted or overlapped edges of the second tape shall be located approximately over the center of the tape in the underlying serving.

17.3.1.2 The thicknesses specified in 17.3.1.1 are to be measured on a specimen removed from the finished cable. The measurements are to be made with a dead-weight dial micrometer whose presser foot has a flat face 0.25 ±0.01 in (6.4 ±0.2 mm) in diameter. The foot is to exert a total of 85 ±3 gf (84 ±0.02 N or 3.0 ±0.1 ozf) on a specimen.

17.3.2 Finish

17.3.2.1 The finish portion of an overall tape-and-finish covering on a Type SE cable shall be of a 75°C (167°F) Class 43 PVC (no oil resistance) having physical properties complying with Table 50.182 of UL 1581 where specimens prepared from samples of the PVC taken from the finished cable are tested as referenced (UL 1581) in the last sentence of 17.2.1.1.

17.3.2.2 The average thickness of the PVC removed from the finished cable shall not be less than 0.030 in (0.76 mm). The minimum thickness at any point of the PVC removed from the finished cable shall not be less than 0.025 in (0.64 mm). The dial micrometer described in 17.3.1.2 is to be used for these measurements.

Table 17.2
Thicknesses of overall jacket on jacketed multiple-conductor Type USE-2 and USE cables

Metal of insulated conductor(s)	AWG or kcmil sizes of Insulated Conductor(s)					inch		(mm)	
	In round cable having one insulated conductor and a concentric uninsulated conductor	In cable with or without a concentric or cabled uninsulated conductor				Minimum average thickness of jacket	Minimum thickness at any point of jacket	Minimum average thickness of jacket	Minimum thickness at any point of jacket
		In round or flat cable having two insulated conductors	In round cable having three insulated conductors	In round cable having four insulated conductors	In round cable having five insulated conductors				
Copper	14 – 3	14 – 10	14, 12	–	–	0.045	0.035	(1.14)	(0.89)
	2 – 2/0	9 – 6	10 – 3	14 – 8	14 – 8	0.060	0.050	(1.52)	(1.27)
	3/0, 4/0	4 – 4/0	2 – 4/0	7 – 2/0	7 – 1/0	0.080	0.065	(2.03)	(1.65)
	–	–	–	3/0, 4/0	2/0 – 4/0	0.110	0.090	(2.79)	(2.29)
Aluminum or copper-clad aluminum	12 – 3	12 – 10	–	–	–	0.045	0.035	(1.14)	(0.89)
	2 – 2/0	9 – 6	12 – 3	12 – 8	12 – 8	0.060	0.050	(1.52)	(1.27)
	3/0 – 300	4 – 300	2 – 300	7 – 2/0	7 – 1/0	0.080	0.065	(2.03)	(1.65)
	–	–	–	3/0 – 300	2/0 – 300	0.110	0.090	(2.79)	(2.29)

ASSEMBLY OF COVERLESS MULTIPLE-CONDUCTOR TYPE USE AND USE-2 CABLES

18 Details

18.1 Single-conductor Type USE and USE-2 cables that individually comply with the requirements in this Standard are to be assembled with or without a bare (metal-coated) or insulated grounded conductor and without any overall covering other than an open, skeleton tape or wrap that, when used, obviously is intended only to hold the cable together. The insulated ungrounded conductors shall all be of the same size (see 12.3). An insulated grounded conductor shall not be smaller than indicated for a bare grounded conductor in Table 18.1 and shall be cabled with two or more insulated ungrounded conductors. One fully insulated grounding conductor that is of the same construction as the circuit conductors is also appropriate in this construction. The grounding conductor, when used, shall be of a size that is not smaller than indicated in Table 19.1 and shall be identified as described in 19.2. A bare grounded conductor (no insulation or other individual nonmetallic covering over the metal-coated copper of the conductor) shall

comply with 18.2. No insulated conductor other than single-conductor Type USE or USE-2 cable, no uninsulated grounding conductor, and no other bare conductor shall be used. Each of these assemblies that includes a bare conductor shall be considered to be a multiple-conductor Type USE or USE-2 cable that is only for direct burial. Each completed coverless cable shall comply with the dielectric and continuity requirements in 18.3 and with the tag, carton, or reel marking required in 47.1(i).

18.2 The bare grounded conductor indicated in 18.1 shall comply with each of the following:

a) The conductor shall be of copper with a metal coating complying with (d) of this paragraph.

b) The conductor shall not be smaller in size than indicated in Table 18.1.

c) The conductor shall be stranded and composed of six or more round wires (strands) that are 14 AWG or larger in size (64.1 mils or 1.63 mm in diameter). See note [c] to Table 18.1.

d) Each wire (strand) of the bare conductor shall be metal-coated. Tin shall be used. The metal coating shall comply with 7.1 – 7.4.

18.3 Where a bare grounded conductor is included in the cable, the completed cable shall be tested for dielectric voltage withstand as indicated in 29.1 – 29.4 with tap water as the outer electrode and the test being made after immersion for at least 60 min. Where a bare grounded conductor is not included, the completed cable either shall be tested in tap water after a 60 min or longer immersion as just indicated or the cable shall be spark tested as required in the Standard for Thermoset-Insulated Wires and Cables (UL 44) with each layer in a multiple-layer cable sparked separately. Each insulated and bare 10 – 14 AWG conductor in the completed cable shall be individually tested for continuity as described in Continuity Test, Section 28.

18.4 In an assembly of two or more insulated conductors, consisting of single-conductor Type USE or USE-2 cables, the lay shall not exceed 60 times the calculated overall diameter of the largest single-conductor cable (including any jacket) in the assembly.

Table 18.1
Smallest size of grounded conductor in coverless Type USE-2 and USE cables

Size of each insulated conductor		Size of grounded conductor	
Copper	Aluminum or copper-clad aluminum	Round cable with 1 insulated conductor over which a bare copper grounded conductor is distributed helically (bare grounded conductor is not to be used parallel to or cabled with the insulated conductor)	Flat cable with 2 insulated conductors laid parallel with a bare or metal-coated copper grounded conductor that is distributed helically (bare grounded conductor is not to be used in valley or valleys) or round cable with 2 or more insulated conductors that are cabled with or without a bare or metal-coated copper grounded conductor that is cabled in one or several sections or is distributed helically: or insulated copper or insulated aluminum grounded conductor that is cabled in on or several sections.
4[a] AWG	2[a]	4 AWG	6[b] AWG
3	1	3	5
2	1/0	2	4

Table 18.1 Continued on Next Page

Table 18.1 Continued

Size of each insulated conductor		Size of grounded conductor	
Copper	Aluminum or copper-clad aluminum	Round cable with 1 insulated conductor over which a bare copper grounded conductor is distributed helically (bare grounded conductor is not to be used parallel to or cabled with the insulated conductor)	Flat cable with 2 insulated conductors laid parallel with a bare or metal-coated copper grounded conductor that is distributed helically (bare grounded conductor is not to be used in valley or valleys) or round cable with 2 or more insulated conductors that are cabled with or without a bare or metal-coated copper grounded conductor that is cabled in one or several sections or is distributed helically: or insulated copper or insulated aluminum grounded conductor that is cabled in on or several sections.
1	2/0	1	3
1/0	3/0	1/0	2
2/0	4/0	2/0	1
3/0	250 kcmil	3/0	1/0
4/0	300	4/0	2/0
250 kcmil	400	250 kcmil	3/0
300	450	300	4/0
350	500	350	250 kcmil
400	600	400	300
450	650	450	350
500	750	500	400
550	850	550	450
600	900	600	500
650	1000	650	550
700	1100	700	600
750	1200	750	650
800	1350	800	700
900	1500	900	800
1000	1750	1000	900
1100	2000	1100	1000
1200	–	1200	1100
1250	–	1250	1150
1300	–	1300	1200
1400	–	1400	1300
1500	–	1500	1400
1600	–	1600	1500
1700	–	1700	1600
1750	–	1750	1650
1800	–	1800	1700
1900	–	1900	1800

Table 18.1 Continued on Next Page

Table 18.1 Continued

Size of each insulated conductor		Size of grounded conductor	
Copper	**Aluminum or copper-clad aluminum**	**Round cable with 1 insulated conductor over which a bare copper grounded conductor is distributed helically (bare grounded conductor is not to be used parallel to or cabled with the insulated conductor)**	**Flat cable with 2 insulated conductors laid parallel with a bare or metal-coated copper grounded conductor that is distributed helically (bare grounded conductor is not to be used in valley or valleys) or round cable with 2 or more insulated conductors that are cabled with or without a bare or metal-coated copper grounded conductor that is cabled in one or several sections or is distributed helically: or insulated copper or insulated aluminum grounded conductor that is cabled in on or several sections.**
2000	–	2000	1900

[a] Cables having insulated conductors smaller than 4 AWG copper or 2 AWG aluminum or copper-clad aluminum are not to have a bare concentric conductor because, in the absence of an overall covering, the unprotected concentric wires are too small to withstand the mechanical forces and corrosive influences normally encountered in direct burial. See 18.2(c).

[b] The six 14 AWG wires (strands) indicated in 18.2(c) fall short of providing the required 6 AWG grounding conductor. In this case, a seventh 14 AWG wire may be added or six round wires at least 66 mils (2.68 mm) in diameter are to be used.

ASSEMBLY OF SUBMERSIBLE PUMP CABLES

19 Details

19.1 The circuit conductors in a cable for use within well casings for wiring deep-well submersible water pumps (see 1.8) shall be an assembly of solid or stranded 14 – 2 AWG copper, 12 – 2 AWG aluminum or copper-clad aluminum, or stranded 1 – 4/0 AWG copper or 1 AWG – 300 kcmil aluminum or copper-clad aluminum conductors. These conductors shall be single-conductor Type USE or USE-2 cables. A grounding conductor is not required. Where used, a grounding conductor shall consist of a fully insulated solid or stranded conductor that is of the same construction of single-conductor Type USE or USE-2 cable as the circuit conductors. The grounding conductor shall be of a size that is not smaller than indicated in Table 19.1 for the largest size circuit conductor used and shall be identified as described in 19.2. All of the conductors in a submersible-pump cable shall be of the same metal. See the required tag marking in 47.1(h) regarding adherence of the insulation to the conductor. See 14.3 for the long-term evaluation of an insulation or jacket material not named or not complying with the specified short-term tests. The circuit and grounding conductors shall be assembled in one of the four following ways:

a) ROUND, JACKETED CABLE – Two through six circuit conductors plus any grounding conductor are to be cabled (length of lay not specified) with an overall 60°C (140°F) jacket. The jacket shall be of CP, thermoset CPE, NBR/PVC, neoprene, or XL in the thicknesses indicated in Table 19.2 for the largest size circuit conductor used and with physical properties complying with Table 50.10 (CP), 50.31 (thermoset CPE), 50.87 (NBR/PVC), 50.112 (neoprene), or 50.230 (XL) in UL 1581. See markings in 40.2 – 40.4.

b) COVERLESS, CABLED ASSEMBLY – Two through six circuit conductors plus any grounding conductor are to be cabled (length of lay not specified) without an overall covering. See markings in 40.3 and 40.4.

c) FLAT CABLE WITH AN INTEGRAL WEB – Two or three circuit conductors of the same size plus any grounding conductor are to be laid flat and parallel to one another with an interconnecting web between adjacent conductors extruded simultaneously with the insulation, integral insulation and jacket, or jacket of the single-conductor Type USE or USE-2 cables that make up the pump cable.

Any grounding conductor that is included and at least one circuit conductor shall be identified by surface striping or word printing. The minimum thickness at any point of the insulation, integral insulation and jacket, or jacket on each circuit conductor and any grounding conductor after separation shall not be less than the minimum thickness at any point indicated for the insulation, integral insulation and jacket, or jacket of single-conductor Type USE or USE-2 cable of the same construction. See markings in 40.2 – 40.4.

d) FLAT, JACKETED CABLE WITH A NONINTEGRAL WEB – Two or three circuit conductors of the same size plus any grounding conductor are to be laid flat and parallel to one another with a nonintegral, overall jacket complying with (a) of this paragraph applied over them. 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. See markings in 40.2 – 40.4.

19.2 An insulated Type USE or USE-2 conductor intended for use as an insulated equipment-grounding conductor shall be finished to show the color green throughout the entire length and circumference of its outer surface with or without one or more straight or helical, broken (non-continuous) or unbroken yellow stripes. See 36.3 for details on stripes. Where there is more than one grounding conductor in an assembly, each must be distinguishable from the other(s) such as, one striped and one not striped. In the case of flat, webbed submersible-pump cable [see 19.1 (c) and (d)] that includes an insulated equipment-grounding conductor, the grounding conductor shall be identified as such either as indicated above in this paragraph or by means of readily legible ink printing of "grounding only", or other wording to the same effect, on the outer surface of the finished conductor.

Table 19.1
Size of grounding conductor where used in Type USE and USE-2 and in submersible pump cables

Size of circuit conductors		Smallest size of grounding conductor of the same metal as the circuit conductors
Circuit conductors of copper	Circuit conductors of aluminum or copper-clad aluminum	
14 AWG	–	14 AWG
12	12 AWG	12
11 – 8	10	10
6 – 3	8 – 6	8
2 – 3/0	4 – 1	6
4/0	1/0 – 4/0	4
–	300 kcmil	2

Table 19.2
Thicknesses of nonintegral jacket on submersible pump cables

AWG size of circuit conductors	Minimum average thickness of jacket		Minimum thickness at any point of jacket	
	mils	(mm)	mils	(mm)
14 – 10	15	(0.38)	12	(0.30)
8 – 2	30	(0.76)	24	(0.61)
1 – 4/0	45	(1.14)	36	(0.91)

PERFORMANCE

20 Flame Test of Cable

20.1 A specimen of finished Type SE cable shall comply with the Cable Flame Test, Section 1061 of UL 1581.

21 Flexibility Test of Cable at Low Temperature

21.1 After cooling for 4 h to −25.0 ±2.0°C (−13.0 ±3.6°F), finished cable shall comply with the requirements of Flexibility at Low Temperature Test, Section 583 of UL 1581. Coverless multiple-conductor Type USE and USE-2 cables, and submersible-pump cables need not be tested where the constituent single-conductor Type USE or USE-2 cables each comply.

22 Cold-Impact Test

22.1 A Type USE cable of any construction is to be considered resistant to a temperature of −40°C (−40° F) when neither the insulation nor the jacket, where applicable, cracks or ruptures when the specimens of the finished cable are subjected to impact at –40.0 ±2.0°C (−40.0 ±3.6°F) as described in Impact at Abnormally Low Temperature Test, Section 593 of UL 1581. Coverless multiple-conductor Type USE cables and submersible-pump cables are not required to be tested when the constituent single-conductor Type USE cables each comply. Such cable is to be marked "−40C" or "minus 40C" on the surface (see 40.9) and on the tag, reel, or carton [see 47.1(i)].

23 Impact-Resistance Test of Single-Conductor Type USE and USE-2 Cables

23.1 The insulation and any jacket of finished 6 AWG copper or 4 AWG aluminum or copper-clad aluminum single-conductor Type USE and USE-2 cables shall keep a free-falling steel weight that impacts the cable with an energy of 5 ft-lbf or 6.8 J or 0.691 m-kgf from making electrical contact with the conductor or from exposing the conductor to view.

23.2 The results of this test on the one indicated size of cable are to be considered representative of the performance of all sizes of copper, aluminum, and copper-clad aluminum cables of the same construction and compound(s).

23.3 The impact anvil is to consist of a steel rod that is mounted on a massive steel block by a disconnectible means such as two bolts that make it possible to replace the rod when its surface has become damaged by repeated impacts. The rod is to be 3/4 in (19 mm) in diameter and 4-3/4 in (121 mm) long. To stabilize the rod on the block, a flat area is to be ground along the entire length of the rod. The plane of the flat area is to be parallel to the longitudinal axis of the rod, and the width of the flat area is to be 1/2 in (13 mm). A hole for a 1/4 in-diameter (19 mm-diameter) bolt is to be drilled through the rod 1 in (25 mm) from each end. The longitudinal axis of each hole is to be perpendicular to the flat area on the centerline of the flat area. The steel block is to be 4-3/4 in long by 2-1/2 in wide by 4 in high (121 mm by 64 mm by 102 mm). The rod is to be bolted to one of the faces of the block that measure 4-3/4 in by 2-1/2 in (121 mm by 64 mm), with the flat area of the rod contacting the face of the block, and with the 4-3/4 in (121 mm) dimensions of the block and rod parallel. The heads of the two bolts are to be countersunk below the surface of the rod to keep them from being struck by the impact weight. A straight line through the center of gravity of the rod is to be coincident with a straight line through the center of gravity of the block and is to be perpendicular to the plane of the surface of the block to which the rod is bolted at the center of that surface of the block. The block is to be secured to a rigid support such as to a vertical steel load-bearing building column or to a concrete floor immediately adjacent to such a column.

23.4 The impact energy is to be supplied by a 5 lb (2.27 kg) steel weight that is 1-1/2 in (38 mm) high and has a flat, rectangular lower surface (the impact face) measuring 4-3/4 in by 2-1/2 in (121 mm by 64 mm).

The edges and corners of the impact face are to be rounded and the longitudinal axis of the weight that is parallel to the 1-1/2 in (38 mm), (height) dimension is to be perpendicular to the plane of the impact face at the center of that face. Opposite sides of the weight are to be flat and parallel to one another and to the longitudinal axis just mentioned. Adjacent sides of the weight are to be mutually perpendicular. The end of the weight that is opposite to the impact face is to have an attachment by means of which the weight can, by machine, be lifted, suspended, and released to fall freely.

23.5 The weight is to be supported with its impact face horizontal. The 4-3/4 in (121 mm) dimensions of the weight and the rod are to be parallel. A vertical line through the centers of gravity of the impact weight and the stationary anvil is to be coincident with a vertical line through the dimensional center of the impact face of the weight. A set of rails or other vertical guide(s) is to constrain the weight and keep its impact face horizontal while the weight is falling and after it has struck the cable. The guide(s) are not to interfere with the free fall of the weight. A mechanism is to be provided at the top of the guide(s) for releasing the weight to fall freely through a height and strike the cable. A means is also to be provided to keep the weight from striking the cable more than once during each drop.

23.6 The cable, the anvil, the weight, and the remainder of the test equipment are to be in thermal equilibrium with one another and the surrounding air at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout the test.

23.7 A representative 100 in (2540 mm) straight length of the finished production cable is to be tested, with any jacket over the insulation remaining in place. The cable is to be tested at each of ten points evenly spaced along its length. These points are not to be closer together than 10 in (254 mm), and no point is to be closer than 5 in (127 mm) to an end of the cable. The weight is to be secured several cable diameters above the rod and the cable is to be placed across the rod with the first test point at the center of the length of the rod. For a distance of at least 10 in (254 mm) to each side of the test point, the longitudinal axis of the cable is to be horizontal, perpendicular to the rod, and in the vertical plane that contains the coincident vertical lines described in 23.5. The conductor in the cable is to be connected in series with a 3-W 120-V neon lamp to the energized conductor of a 120-V 48 – 62 Hz a-c 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.

23.8 The position of the weight is to be adjusted to place the lower, impact face of the weight 12 in (305 mm) above the upper surface of the cable. The weight is to be released from this height, is to fall freely in the guide(s), is to strike the cable once, and is then immediately to be raised to and secured at the 12 in (305 mm) height. Each of the remaining nine test points on the cable is to be impacted in succession in the same way. When the conductor is visible at any of the ten test points or when the lamp lights momentarily or longer at more than two of the test points the cable does not comply with the impact-resistance test.

24 Crushing-Resistance Tests of Single-Conductor Type USE and USE-2 Cables

24.1 In each of three tests, an average of at least the following specified force shall be necessary to crush finished 6 AWG copper (4 AWG) aluminum or copper-clad aluminum single-conductor Type USE and USE-2 cables to the point that electrical contact is made between the conductor in the cable and either of the metal plates between which the cable is crushed:

a) TEST without CURRENT – 1000 lbf or 4448 N or 454 kgf without any current flowing in the cable.

b) TEST with RATED CURRENT – 800 lbf or 3559 N or 363 kgf with the cable carrying the free-air 75°C (167°F) wet-locations rated current (see 24.5) for a single Type XHHW conductor of the same size.

c) TEST with OVERLOAD CURRENT – 600 lbf or 2669 N or 272 kgf with the cable carrying a current (see 24.6) that maintains the temperature of the conductor at 100.0 ±2.0°C (212.0 ±3.6°F).

24.2 The results of these three tests on the one indicated size of cable are to be considered representative of the performance of all sizes of copper, aluminum, and copper-clad aluminum cables of the same construction and compound(s).

24.3 For each of the three tests, a separate representative minimum 100 in (2540 mm) straight length of the finished production cable is to be tested. Any jacket over the insulation is to remain in place. The cable is to be tested at each of ten points along its length. These points are not to be closer together than 10 in (254 mm), and no point is to be closer than 5 in (127 mm) to an end of the cable. Each test point on the cable is to be placed between 2 in wide (50 mm wide) flat, horizontal steel plates in a compression machine whose jaws close at the rate of 0.50 in/min ±0.05 in/min (10 mm/min ±1 mm/min). Each plate is to be at least 0.5 in (12.7 mm) thick. The cable is to be parallel to the 2 in (50 mm) dimension of the plates and the cable is to be straight and horizontal for a distance of at least 10 in (254 mm) to each side of the test point. The conductor in the cable is to be connected in series with a light-emitting diode (LED) and a current-limiting resistor to one terminal of a battery. The plates are to be connected together, to the metal of the testing machine, to earth ground, and to the second terminal of the battery, see Figure 24.1.

24.4 For the test without current, the cable, the test equipment, and the surrounding air are to be in thermal equilibrium with one another at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout the test.

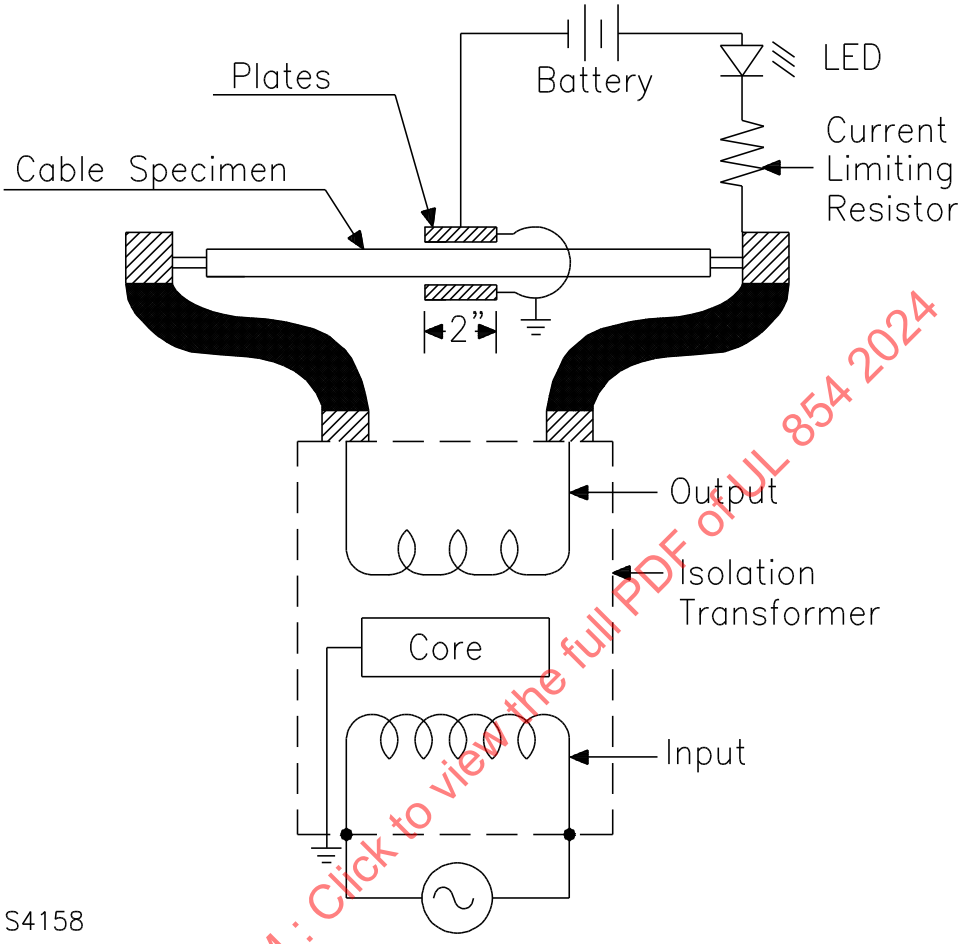
24.5 For the test with rated current, the conductor in the cable is to be connected to the low-voltage output of an isolation transformer. The core of the transformer is to be connected to earth ground. The output winding of the transformer is not to be grounded. A current of 95 A is to flow in the conductor when the conductor is 6 AWG copper. A current of 100 A is to flow in the conductor when the conductor is 4 AWG aluminum or copper-clad aluminum. This current is to flow for 60 min previous to the start of the test and is to flow throughout the test. The test equipment and the surrounding air are to be in thermal equilibrium with one another at a temperature of 23.0 ±5.0°C (73.4 ±9.0F) throughout this test.

24.6 For the test with overload current, a thermocouple is to be soldered or cemented to the metal conductor in the center third of the length of the cable, with the insulation and any jacket replaced over the thermocouple and sealed with a minimum amount of masking tape. The conductor in the cable is to be connected to the low-voltage output of an isolation transformer. The core of the transformer is to be connected to earth ground. The output winding of the transformer is not to be grounded. The conductor is to carry a current of a magnitude that results in a temperature of 100.0 ±2.0°C (212.0 ±3.6°F) on the surface of the metal conductor under the insulation as registered by the thermocouple. The current is to be adjusted as necessary to maintain the temperature of the conductor in the indicated range for 60 min previous to the start of the test and throughout the test. The test equipment and the surrounding air are to be in thermal equilibrium with one another at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout this test. The temperature of the conductor is to be recorded as the cable is tested at the first and last test points.

24.7 In each of the three tests, the ten test points of the cable are to be subjected in succession to an increasing force until electrical contact occurs (as indicated by the LED lighting) between the conductor in the cable and one or both of the metal plates. The force at which the contact occurs is to be recorded for each of the ten test points. In each test, the sum of the ten forces is to be divided by 10 to obtain the average crushing force for the cable. When the average force obtained in any of the three tests is less than specified in 24.1 (a), (b), or (c) the cable does not comply with the crushing-resistance test.

Figure 24.1

Wiring diagram for crushing-resistance test



25 Overload Test of Single-Conductor Type USE and USE-2 Cables

25.1 Finished 6 AWG copper or 4 AWG aluminum or copper-clad aluminum single-conductor Type USE and USE-2 cables shall not rupture or flame at any time as the result of heating of the conductor by the following currents flowing in immediate succession as described in 25.4:

a) 150 A for 30 min.

b) 175 A for 5 min.

c) 200 A for 5 min.

d) 225 A for 5 min.

e) 250 A for 5 min.

f) 275 A for 5 min.

g) 300 A for the short time that it takes to adjust the current from a constant 275 A to a constant 300 A.

25.2 The results of this test on the one indicated size of cable are to be considered representative of the performance of all sizes of copper, aluminum, and copper-clad aluminum cables of the same construction and compound(s).

25.3 One representative 11 ft (3.5 m) straight length of the finished production cable is to be tested. Any jacket over the insulation is to remain in place. The cable is to be laid straight down the center of a straight, flat-bottomed trough that is open at the top and ends and has side walls to retain any hot material that erupts from the cable. The trough is to be made of soft wood nominally 3/4 in (20 mm) thick and is to be lined with fire-resistant, chemically-inert, and electrically-nonconductive sheeting. The finished trough is to have approximately the following inside dimensions: 12 ft long by 10 in wide by 9 in deep (3.75 m long by 250 mm wide by 225 mm deep). At each end of the cable, the conductor is to be stripped for a short length and connected by means of a connector that is intended for the purpose to the low-voltage output of an isolation transformer. The core of the transformer and one side of the output winding are to be connected to earth ground. The air in the test room is to be at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout the test. Air movement in the test area is to be minimal.

25.4 Current is to be started flowing in the conductor, is to be quickly adjusted to 150 A, and then is to be held constant at 150 A. The start of the flow of current is to activate a timer. As soon as the timer indicates that 30 min have elapsed since the start of the flow of current, the current is to be quickly increased to 175 A and then held constant at 175 A. As soon as the timer indicates that 5 min have elapsed since the current was at the 150 A level, the current is to be quickly increased to 200 A and held constant at that level until 5 min have elapsed since the current was 175 A. The current is to be further increased and held constant in this manner in increments of 25 A, with the short time for adjustment included at the beginning of each 5 min period. This is to continue until the current has been adjusted to a constant 300 A. The current is not to be held at 300 A. As soon as the 300 A current is constant, it is to be reduced to zero and the test is to be discontinued. The cable does not comply with the overload test when it ruptures or flames at any time during the flow of current or after the current is reduced to zero.

26 Overload Test of Conductors in Jacketed, Multiple-Conductor Type USE and USE-2 Cables

26.1 Jacketed, multiple-conductor Type USE and USE-2 cables containing either of the following shall not flame or rupture while a current of 150 A is flowing through all of the conductors in the cable connected in series for 60 min as described 26.2:

a) Three insulated 6 AWG copper conductors or two insulated 6 AWG copper conductors and a 6 AWG uninsulated copper conductor, or

b) Three insulated 4 AWG aluminum or copper-clad aluminum conductors or two insulated 4 AWG aluminum or copper-clad aluminum conductors and a 4 AWG aluminum or copper-clad aluminum uninsulated conductor.

This requirement applies to cable with an uninsulated conductor regardless of how the conductor is assembled into the cable – cabled in one or several sections, laid straight in one or both valleys, or distributed helically.

26.2 One 11 ft (3-1/2 m) specimen of finished cable with 6 in (150 mm) of the overall covering removed from each end is to be placed in a straight, open (open top and ends), flat-bottomed trough with side walls to retain any hot material. The trough is to be made of soft wood nominally 3/4 in (20 mm) thick; is to be lined with fire-resistant, chemically-inert, and electrically-nonconductive sheeting; and is to have inside dimensions of approximately 12 ft by 10 in wide by 9 in deep (3-3/4 m long by 250 mm wide by 225 mm) deep. The conductors are to be connected in series by means of short jumpers at each end of the specimen. At each end of the specimen, connection (by means of a connector intended for the purpose) is to be made between a source of alternating or direct current and the free conductor. A current of 150 A is to be maintained in the conductors for 60 min. Any cable from which a specimen flames or ruptures during the 60 min does not comply with the overload test.

27 Overload Test of Uninsulated Conductor in Type SE Cable

27.1 A Type SE cable containing the following shall not flame or rupture while a current of 300 A is flowing through the uninsulated conductor for 60 min as described in 27.2.

a) Two parallel insulated 6 AWG copper conductors and a 6 AWG concentric copper uninsulated conductor or two parallel insulated 4 AWG aluminum or copper-clad aluminum conductors and a 4 AWG concentric aluminum or copper-clad aluminum uninsulated conductor.

b) Three insulated 6 AWG copper conductors and a 6 AWG copper uninsulated conductor or three insulated 4 AWG aluminum or copper-clad aluminum conductors and a 4 AWG aluminum or copper-clad aluminum uninsulated conductor.

27.2 One 11 ft (3-1/2 m) specimen of finished cable with 6 in (150 mm) of the overall covering removed from each end is to be placed in a straight, open (open top and ends), flat-bottomed trough with side walls to retain any hot material. The trough is to be made of soft wood nominally 3/4 in (20 mm) thick; is to be lined with fire-resistant, chemically-inert, and electrically-nonconductive sheeting; and is to have inside dimensions of approximately 12 ft by 10 in wide by 9 in deep (3-3/4 m by 250 mm wide by 225 mm) deep. At each end of the specimen, connection (by means of a connector intended for the purpose) is to be made between a source of alternating or direct current and the uninsulated conductor. A current of 300 A is to be maintained in the cable for 60 min. Any cable from which a specimen flames or the tape portion of the tape and finish covering described in 17.3 ruptures during the 60 min does not comply with the overload test.

28 Continuity Test

28.1 Finished cable shall be tested for continuity of each 14 – 10 AWG conductor by the cable manufacturer at the cable factory.

28.2 To determine whether or not the conductor(s) in a finished cable are continuous, the single-conductor or each of the conductors (one at a time) is to be connected in series with a lamp, buzzer, bell, or other indicator and a power supply. The conductor is continuous from end to end of the finished cable when the lamp lights, the bell or buzzer sounds, or the other indicator signals.

28.3 For the factory production continuity testing of a single-conductor Type USE cable, it is appropriate for the manufacturer to substitute a continuous eddy-current procedure complying with 28.4 and 28.5 for the test in 28.2.

28.4 The eddy-current test arrangement shall include equipment that complies with each of the following:

a) The equipment is to apply current at one or several frequencies in the range of 1 – 125 kHz to a test coil for the purpose of inducing eddy currents in the conductor moving through the coil at production speed.

b) The equipment is to detect the variation in impedance of the test coil caused by each break in the conductor.

c) The equipment is to provide a visual indication to the operator.

28.5 The longitudinal axis of the cable or assembly is to be coincident with the electrical center of the test coil. The cable is to have little or no vibration as it passes through the test coil and is to clear the coil by a distance no greater than 1/2 in (13 mm). Variations in the speed of the cable through the test coil are to be limited to plus 50 percent and minus whatever percentage (50 percent maximum) keeps the signal amplitude from falling below the level at which a break can be detected. Separate calibration, balance, and adjustments for sensitivity, maximum signal-to-noise ratio, and maximum rejection of signals indicating gradual variations in diameter and other slow changes are to be made for each size, type of stranding, and conductor material. Calibration without any cable in the test coil is to be made at least daily to check whether the equipment is functioning. The temperature along the length of the cable being tested may vary from the temperature at which the equipment was calibrated, balanced, and so forth for that size, type of stranding, and conductor material provided that the variations are gradual and are without hot or cold spots that cause false signals.

29 Dielectric Voltage-Withstand Test(s)

29.1 A finished cable shall not break down electrically while being stressed with 48 – 62 Hz essentially sinusoidal rms potential as indicated in 29.2 – 29.4 (see 18.3 for the modified method applicable to coverless multiple-conductor Type USE and USE-2 cables).

29.2 The apparatus for this test is to consist of a circuit breaker or other means of indicating a breakdown, a tank of earth-grounded tap water to serve as an electrode in the case of cable in which there is no uninsulated conductor, and a testing transformer complying with the following. The water is to be at any convenient temperature. An rms test potential of at least the value indicated in Table 29.1 for the insulated conductor(s) used in the cable is to be supplied by a 48 – 62 Hz isolation transformer whose rms output potential is continuously variable from zero to at least the specified potential at a rate not higher than 500 V/s. With a specimen in the circuit, the output 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 output voltage is to be monitored continuously by a voltmeter that:

a) When 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,

b) Has an overall accuracy that does not introduce an error exceeding 5 percent.

The maximum current output of which the transformer is capable shall make it possible to routinely test full reels of the cable without tripping of the circuit breaker by the charging current.

Table 29.1
Dielectric test potential

Size of insulated conductor(s)	RMS test potential in volts
14 – 10 AWG	3,000
9 – 2	3,500
1 – 4/0	4,000
213 – 500 kcmil	5,000
501 – 1000	6,000
1001 – 2000	7,000

29.3 Finished cable having an uninsulated conductor and an overall covering is to be tested dry. Finished cable without an uninsulated conductor is to be immersed in water for at least 60 min before being tested. The rms test potential specified for the insulated conductor(s) in Table 29.1 is to be applied (as indicated in 29.4) between each insulated conductor taken separately and either:

a) The uninsulated conductor when one is employed, or

b) The water when no uninsulated conductor is in the cable.

In a cable with more than one insulated conductor, an alternative method is to conductively connect the insulated conductors together and apply the specified test potential between them and any uninsulated conductor or the water. In addition, in a cable with more than one insulated conductor, the specified test potential is to be applied (as indicated in 29.4) between each insulated conductor and every other insulated conductor in the cable.

29.4 In every case, the applied potential is to be increased from zero at a uniform rate that:

a) Is not less than 10 V/s, and

b) Is not more than 60 V/s.

The increase is to continue in this manner until the voltage reaches the level specified. When this level is reached without breakdown, the voltage is to be held constant at the specified level for 60 s and is then to be reduced to zero. The cable does not comply with the requirement when electrical breakdown occurs at less than the specified voltage while the applied voltage is being increased or in less than 60 s at the specified voltage.

30 Sunlight-Resistance Tests

30.1 Insulation

30.1.1 The insulation of all jacketed cables shall comply with the Sunlight Resistant test described in 30.3.1 after 300 hours of xenon-arc exposure.

30.1.2 The insulation of all unjacketed cables shall comply with the Sunlight Resistant test described in 30.3.1 after 300 hours of xenon-arc exposure, unless the cable is marked “sunlight Resistant” in accordance with 40.7, in which case the insulation shall comply with the Sunlight Resistant test described in 30.3.1 after 720 hours of xenon-arc exposure.

30.2 Jacket

30.2.1 With the exception of submersible pump cable, the jacket on all cables marked sunlight resistant in accordance with 40.7 shall comply with the sunlight resistance test described in 30.3.1 after 720 hours of xenon-arc exposure.

30.2.2 With the exception of submersible pump cable, the jacket on all cables marked sunlight resistant in accordance with 40.8 shall comply with the sunlight resistance test described in 30.3.1 after 300 hours of xenon-arc exposure.

30.3 Test Method

30.3.1 The Sunlight Resistance tests shall be conducted in accordance with the test Sunlight Resistance, as described in the Standard for Wire and Cable Test Methods, UL 2556. The average tensile strength and ultimate elongation retained after 300 h of xenon-arc exposure shall not be less than 85 percent of the average tensile strength and ultimate elongation of unconditioned specimens. The average tensile strength and ultimate elongation retained after 720 h of xenon-arc exposure shall not be less than 80 percent of the average tensile strength and ultimate elongation of unconditioned specimens.

30.3.2 Cable that does not comply with the requirement in 30.3.1 for 85 percent or better retention of tensile strength and ultimate elongation after 300 h of xenon-arc exposure is eligible to have its performance reevaluated on the basis of the results of testing after 100, 300, and 500 h of xenon-arc exposure. Five specimens are to be conditioned for each of the three indicated lengths of time. The cable is appropriate for use when the results of this testing comply with each of the following requirements:

a) The average tensile strength and ultimate elongation retained after 100 h of xenon-arc exposure shall not be less than 65 percent of the average tensile strength and ultimate elongation of unconditioned specimens.

b) The rate of decrease of the percent retention of average tensile strength and ultimate elongation from 100 h to 300 h of xenon-arc exposure shall not exceed 15.

c) The rate of decrease of the percent retention of average tensile strength and ultimate elongation from 300 to 500 h of xenon-arc exposure shall not exceed 5.

31 Vertical-Tray Flame Test (Type SE)

31.1 All sizes of finished Type SE cables that are marked (see 40.6) for use in cable trays are appropriate for use in cable trays when two sets of specimens of the finished 3-conductor construction containing two 6 AWG insulated conductors and a concentric uninsulated conductor are tested in accordance with the UL Flame Exposure, Sections 4 – 11 of the requirements for vertical-tray fire-propagation and smoke-release test for electrical and optical-fiber cables of UL 1685, or the FT4/IEEE 1202 Type of Flame Exposure, Sections 12 – 19 of UL 1685 and comply with the requirements therein. Smoke measurements are not applicable.

32 Low-Temperature Pulling-Through-Joists Test

32.1 Finished Type SE cable with or without an uninsulated conductor shall be constructed to withstand the low-temperature pulling-through-joists test described in 32.1 – 32.8 without damage to the overall tape-and-PVC-finish covering to the extent that the parts of the cable underlying the covering are exposed to view. The cable does not comply with the requirement when the interior of the cable is exposed on either of two test lengths, however both lengths shall be tested. See the second sentence of 32.8.

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

32.3 By means of a power wood auger, two holes of the diameter indicated in Table 32.1 are to be bored (at a speed of 1800 r/min) through the broad faces of each length of 2 by 4 as shown in Figure 32.1. 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 2-3/8 in (60 mm) apart. No attempt is to be made to smooth or round the edges of the holes or to remove splintered wood, sawdust, or drilling chips from the holes.

Table 32.1
Size of hole

Calculated diameter over finished round cable or length of major axis of finished flat cable		Nominal diameter of each round hole in blocks of wood	
inches	**(mm)**	**inches**	**(mm)**
Not over 0.710	(Not over 18)	1-1/8	(29)
Over 0.710 but not over 0.800	(Over 18 but not over 20)	1-1/4	(32)
Over 0.800 but not over 0.875	(Over 20 but not over 22)	1-3/8	(35)
Over 0.875 but not over 0.950	(Over 22 but not over 24)	1-1/2	(38)
Over 0.950 but not over 1.025	(Over 24 but not over 26)	1-5/8	(41)