UL 1690

STANDARD FOR SAFETY

Data-Processing Cable

UL Standard for Safety for Data-Processing Cable, UL 1690

Fourth Edition, Dated July 7, 2015

Summary of Topics

This revision of ANSI/UL 1690 dated August 7, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated May 15, 2020.

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UL 1690

Standard for Data-Processing Cable

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Fourth Edition

July 7, 2015

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through August 7, 2020.

The most recent designation of ANSI/UL 1690 as a Reaffirmed American National Standard (ANS) occurred on August 7, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electrical cables consisting of one or more current-carrying copper, aluminum, or copper-clad aluminum conductors with or without either or both grounding conductor(s), and one or more optical-fiber members, all under an overall jacket. These electrical and composite electrical/optical-fiber cables are intended for use (optical and electrical functions associated in the case of a hybrid cable) in accordance with Article 645 and other applicable parts of the National Electrical Code (NEC) under the raised floor of a computer room.

Cables complying with these requirements are:

Type DP-1 – Voltage Rating 600 volts, Flame Test: 1.2 (b)

Type DP-1P – Same as Type DP-1 except Flame Test: 1.2 (a)

Type DP-2 – Voltage Rating: 300 volts, Flame Test: 1.2 (b)

Type DP-2P – Same as Type DP-2 except Flame Test: 1.2 (a)

Type DP-3 – Voltage Rating none – for use in signaling circuits meeting the following requirements for maximum available voltage, current and power.

30 volts ac max.		other circuits for use in
60 volts dc max.		inherently limited power
42.4 volts peak max.	and/or	sources in accordance with
100 VA max.		the requirements in the Standard
8 amps max.		for Safety of Information Technology
		Equipment – UL 60950

Flame Test: 1.2 (b)

Type DP-3P – Same as Type DP-3 except Flame Test: 1.2 (a)

1.2 Smoke and fire considerations are as follows for the cables covered in the requirements:

a) TYPE DP-1P, DP-2P and DP-3P CABLES – These cables are to be tested for smoke and flame characteristics in accordance with the National Fire Protection Association Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces, ANSI/NFPA 262. A cable that complies exhibits a maximum flame-propagation distance that is not greater than 5 ft, 0 in, or 1.52 m, a peak optical density of smoke produced of 0.5 or less (32 percent light transmission), and an average optical density of smoke produced of 0.15 or less.

b) TYPE DP-1, DP-2, and DP-3 CABLES – Cables comply with a 70,000 Btu/h (20.5 kW) vertical-tray flame test. The cable manufacturer chooses one of the following tests:

1) THE UL TEST REFERENCED IN 30.2.1 – This paragraph applies the test method described as the UL Flame Exposure (smoke measurements are not applicable) in the Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685. For compliance, this test damages less than 8 feet (244 cm) of cable.

2) THE FT4/IEEE 1202 TEST REFERENCED IN 30.3.1 – This paragraph applies the test method described as the FT4/IEEE 1202 Type of Flame Exposure (smoke measurements are not applicable) in the Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685. For compliance, this test damages less than 150 cm (59 inches) of cable.

1.3 A cable that contains one or more electromagnetic shields may be surface marked or have a marker tape to indicate that it is "shielded". A cable that contains one or more optical-fiber members has "-OF" supplementing the type letters and is limited (see 14.2) to carrying optical energy that has been ruled not hazardous to the human body. A cable may consist of or contain one or more coaxial members.

1.4 These cables may contain one or more metal shields but do not have a metal sheath or armor. Electrical cables with a metal sheath or armor are covered as Type MC in the Standard for Metal-Clad Cables, UL 1569, or Type AC in the Standard for Armored Cable, UL 4.

1.5 These requirements do not cover the optical or other performance of any optical-fiber member or group of such members.

2 Units of Measurement

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

3 References

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

3.2 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.

CONSTRUCTION

4 Materials

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

4.2 Data Processing cable shall be designated as Type DP and shall comply in all respects with the applicable requirements for construction details, test performance, and markings.

5 Conductors

5.1 The conductor shall be of soft-annealed copper, high-conductivity copper alloy, copper-clad aluminum, copper-clad steel or an acceptable aluminum alloy. Soft-annealed copper shall comply with ASTM B 3. Copper alloy shall comply with ASTM B 624. A metal coating that is provided on soft-annealed copper, on copper alloy, or on copper-clad aluminum in compliance with Section 8 shall be of tin complying with ASTM B 33, of a tin/lead alloy complying with ASTM B 189, of nickel complying with ASTM B 355, of silver complying with ASTM B 289, or of another metal or alloy (evaluation required). Solid aluminum conductors in size Nos. 12 – 8 AWG shall comply with the requirements for aluminum wire stock (aluminum-alloy conductor material). All other aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in Section 10 of UL 1581. Copper-clad aluminum conductors shall comply with the requirements in Section 11 of UL 1581.

5.2 Each conductor shall be continuous throughout the entire length of the finished cable – see test in 17.1 and 17.2.

6 Size, Temper, and Assembly

6.1 Conductors shall be of the size, temper, and assembly indicated for the finished wire type in Table 6.1.

Table 6.1
Conductors

Cable type	Sizes of aluminum or copper-clad aluminum conductors	Sizes of soft-annealed copper conductors	Sizes of solid or stranded copper-clad steel or copper alloy conductors
DP-1	12 AWG – 1000 kcmil	18 AWG – 1000 kcmil	None
DP-2	12 – 8 AWG	24 – 8 AWG	None
DP-3	None	30 – 10 AWG[a]	30 – 10 AWG[a]

[a] Nos. 11 and 10 AWG copper conductors and No. 10 AWG and smaller copper-clad steel or copper alloy conductors are only for the central conductor in a coaxial member.

7 Conductor Diameter and Cross-Sectional Area

7.1 The nominal, maximum (1.01 × nominal), and minimum (0.98 × 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 Section 200 of UL 1581. The sizes of the various types of wire are indicated in Table 6.1.

7.2 Compressed unilay copper conductors that are smaller in diameter than the requirement (0.98 × nominal in Table 20.1 of UL 1581) for compressed concentric lay conductors shall be marked the same as compact conductors in accordance with 38.1.

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

8 Metal Coating

8.1 If the insulation adjacent to a copper, copper alloy, copper-clad aluminum, or copper-clad steel conductor is of a material that corrodes unprotected copper in the test in 500.1 of UL 1581, and if a protective separator is not provided, the solid conductor and each of the individual strands of a stranded conductor shall be separately covered with a metal or alloy coating complying with 5.1 as applicable to the finished wire type.

8.2 In the case of a stranded conductor on which a coating is not needed for corrosion protection but is solely to keep the insulation from adhering to copper, it is acceptable to coat only the wires of the outer layer.

8.3 The maximum temperature rating of the cable is not specified relative to the diameter of copper wires used in the serving, wrap, or braid shielding described in item (b) of 15.5.2. Otherwise, copper strands and solid copper conductors shall not be used in a cable with a temperature rating higher than indicated in

Table 8.1. Aluminum or copper-clad aluminum conductors shall not be used in a cable with a temperature rating higher than 90°C (194°F).

Table 8.1
Maximum temperature rating of cable relative to diameter and coating of solid copper conductor or of copper conductor strands

Metal coating of copper strands or of solid copper conductor	Diameter of each strand or of the solid conductor	
	Smaller than 0.015 inch or 0.38 mm	At least 0.015 inch or 0.38 mm
Uncoated or coated with tin or a tin/lead alloy	150°C (302°F)	200°C (392°F)
Coated with silver	200°C (392°F)	200°C (392°F)
Coated with nickel	over 200°C (392°F)	200°C (392°F)

9 Separator

9.1 A separator is acceptable between the conductor and the insulation of a solid or stranded wire or cable, but is not required. A separator shall be insulating but shall not be considered to be part of the required insulation.

9.2 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 green or green and yellow and may be solid, striped, or in some other pattern.

10 Joints

10.1 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall be made in a workmanlike manner, shall be essentially smooth, and shall not have any sharp projections. A joint in a stranded conductor may be made by:

a) Separately joining each individual wire, or

b) For Type DP-3 only by machine brazing or welding of the conductor as a whole

provided that the resulting solid section of the stranded conductor is not longer than 1/2 in or 13 mm, there are no sharp points, and the distance between brazes or welds in a single conductor does not average less than 3000 ft or 915 m in any reel length of insulated single conductor. A joint made before insulation is applied to a conductor shall not increase the diameter of the solid conductor or individual wire (strand). For Type DP-3 only, a joint made after insulating shall not increase the diameter of the solid conductor or individual wire (strand) by more than 20 percent. The insulation applied to joints after insulating shall be equivalent to that removed and shall comply with the requirements in this standard. Heat-shrinkable tubing, bonded patch, and molding is accepted for Type DP-3 but taping is not. A joint in a compact- or compressed-stranded conductor shall not be made before compacting or compressing.

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

11 Resistance

11.1 The direct-current resistance of any length of conductor shall not be higher than the maximum acceptable (nominal × 1.02) indicated in the applicable one of the eleven Tables 30.1 – 30.11 of UL 1581 at 20°C (68°F) or at 25°C (77°F) or in Table 11.1 of this Standard when measured as described in 220.1 – 220.9 of UL 1581.

Table 11.1
Maximum acceptable direct-current resistance of solid copper conductors

AWG size of conductor	Uncoated				Coated			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer
30	114	374	117	384	119	390	121	397
29	89.3	293	91.1	299	92.9	305	94.7	311
28	71.8	236	73.3	240	74.7	245	76.2	250
27	56.5	185	57.6	189	58.8	193	59.9	197
26	45.1	148	46.0	151	46.9	154	47.8	157
25	35.6	117	36.3	119	37.0	121	37.7	124
24	28.6	93.8	29.2	95.8	31.5	103	32.1	105
23	22.3	73.2	22.7	74.5	23.2	76.1	23.7	77.8
22 DP2	16.5	54.1	16.8	55.1	17.2	56.4	17.5	57.4
22 DP3	18.0	59.1	18.4	60.4	19.8	65.0	20.2	66.3
21 DP2	13.1	43.0	13.3	43.6	13.6	44.6	13.8	45.3
21 DP3	14.1	46.3	14.4	47.2	14.7	48.2	15.0	49.2
20 DP2	10.3	33.8	10.5	34.5	10.7	35.1	10.9	35.8
20 DP3	11.1	36.4	11.3	37.1	11.6	38.1	11.8	38.7
19 DP2	8.21	26.9	8.37	27.4	8.54	28.0	8.70	28.5
19 DP3	8.86	29.1	9.04	29.7	9.21	30.2	9.39	30.8
18	6.52	21.4	6.65	21.8	6.78	22.2	6.91	22.7
17	5.15	16.9	5.25	17.2	5.36	17.6	5.47	17.9
16	4.10	13.5	4.18	13.7	4.26	14.0	4.35	14.3
15	3.24	10.6	3.30	10.8	3.37	11.1	3.43	11.3

12 Stranding

12.1 A stranded wire or cable shall have the number of strands indicated in Table 12.1. Copper strands smaller than No. 36 AWG shall not be used on 24 AWG and larger conductors. Aluminum or copper-clad aluminum strands smaller than No. 22 AWG shall not be used. A compact-stranded conductor shall not be segmented.

Table 12.1
Conductor stranding

Size of wire	Number of strands in combination unilay	Minimum number of strands	
		Compact stranded	All others
30 – 13 AWG	–	–	7
14 and 13	19 (copper only)	–	7
12 – 9	19 (copper only)	7	7
7 – 2	19	7	7
1 – 4/0	19	18	19
213 – 500 kcmil	–	35	37
501 – 1000	–	58	61

12.2 The individual wires used in making up a stranded conductor are usually drawn to a specified mil diameter which may or may not be the diameter of any AWG or other standard gauge number. The individual wires of a concentric-lay-stranded conductor are not necessarily all of the same diameter.

12.3 A 19-wire combination round-wire unilay-stranded soft-annealed copper or aluminum conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire with the six wires having identical lengths of lay, and an outer layer consisting of six wires of the same diameter as the central wire alternated with six smaller wires having a diameter of 0.732 times the diameter of the central wire and with all twelve wires of the outer layer having the same length of lay and direction of lay as the six wires of the inner layer. No particular assembly of the individual wires of any other stranded conductor is required, but simple bunching (untwisted strands) shall not be used for the entire conductor or any part thereof. The length of lay of the strands in a single-bunch bunch-stranded conductor shall not be greater than indicated in Table 12.2. The direction of lay of the strands in a single-bunch bunch-stranded conductor shall be left-hand. Any type of stranding in Table 210.2 of UL 1581 other than compact stranding or single-bunch-stranding shall comply with the applicable 12.4, 12.5, or 12.6. The direction of lay of the outer layer shall be left-hand in all cases.

Table 12.2
Length of lay of strands in a single-bunch bunch-stranded conductor[a]

AWG size of conductor	Maximum acceptable length of lay	
	inch	mm
18	1	25
16	1-1/4	32
14	1-5/8	41
13	1-5/8	41
12	2	51
11	2	51
10	2-1/2	64
9	2-1/2	64
8	2-3/4	70
7	3	76
6	3-3/8	86
larger than 6	16 times the conductor diameter	

[a] Includes the constructions in note [a] to Table 210.2 of UL 1581.

12.4 A compact-stranded conductor shall be a round aluminum conductor consisting of a central core wire surrounded by one or more layers of helically laid wires with all layers having the same direction of lay (left-hand unidirectional) and with each layer rolled, drawn, or otherwise compressively formed to distort the originally round or partially preshaped strands to various close fitting shapes that achieve almost complete filling of the spaces originally present between the strands. Each layer shall be compacted before the next layer is applied, and each compacted layer – including the outermost layer – shall have an essentially smooth, round outer surface. The overall diameter of the finished, compacted conductor shall not be larger than indicated in column C or D of Table 20.2 of UL 1581. The length of lay of the strands in the outer layer of a No. 1 AWG – 4/0 AWG conductor shall be 8 – 16 times the overall diameter of that layer. The length of lay of the strands in the outer layer of a No. 12 – 2 AWG conductor shall be 8.0 – 17.5 times the overall diameter of that layer.

12.5 A compressed-stranded conductor shall be a round conductor consisting of a central core wire surrounded by one or more layers of helically laid wires with, for the No. 6 AWG – 1000 kcmil sizes, the direction of lay reversed in successive layers. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers are to be slightly compressed by rolling, drawing, or other means to change the originally round strands to various shapes that achieve filling of some of the spaces originally present between the strands. A finished compressed-stranded ASTM Class B, C, or D conductor shall not be larger or smaller in overall diameter than indicated in Table 20.3 of UL 1581.

12.6 Every stranded conductor covered in Table 210.2 of UL 1581 other than a compact-stranded conductor or a single-bunch bunch-stranded conductor shall comply with the following:

a) The direction of lay of the strands, members, or ropes in a No. 6 AWG – 1000 kcmil conductor other than a combination unilay or compressed-unidirectional-lay conductor shall be reversed in successive layers. Rope-lay conductors with bunch-stranded or concentric-stranded members shall be either unidirectional or reversed. All unidirectional lays and the outer layer of reversed lays shall be in the left-hand direction.

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

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

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

e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of the conductor.

f) The length of lay of the members or ropes in the outer layer of a rope-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer.

13 Insulation

13.1 Material and Application

13.1.1 Each conductor shall be insulated for its entire length with one or more of the insulation materials indicated in Table 13.1 or referenced in note a to Table 13.1. The insulation shall be solid or, in the cases indicated in the second column of Table 13.1, may be expanded or foamed. In any case, a solid dielectric skin (a thin, solid, extruded layer that may or may not be separable) of the same or other material from Table 13.1 may be applied over the solid insulation or over the foam. The material insulation in an air-gap coaxial member shall consist of a solid tube over a solid spacer (thread) that has a nominally circular cross section and is applied to the conductor helically in a continuous length (length of lay is not specified). Otherwise, the insulation shall be applied directly to the conductor, shall have a circular cross section, and shall fit tightly to the conductor but shall not adhere excessively. The insulation shall be uniform and shall not have any defects (bubbles, open spots, rips, tears, cuts, or foreign material) that are visible with normal or corrected vision without magnification. The use of foamed or expanded insulation or an air-gap construction is limited to Type DP-3 series cables.

13.1.2 Either of the following materials that the manufacturer wishes to use as 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 named in Table 13.1 or Table 16.1 (new material).

b) Material that is named in Table 13.1 or Table 16.1 yet does not comply with the short-term tests specified for the material.

The temperature rating of materials (a) and (b) shall be as required for the specific data-processing cable type. The thicknesses of insulation and/or jacket using materials (a) and/or (b) shall be as required for the 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 an insulation or jacket material named in Table 13.1 or Table 16.1 for the required temperature rating. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock, insulation resistance, and dielectric voltage-withstand.

Table 13.1
Index to insulations

Material(s)[a]	Temperature rating of insulation	Applicable table of physical properties in UL 1581 (see 13.2)
CP	90°C (194°F)	
	solid	50.1
	75°C (167°F)	
	solid	50.1
ECTFE	150°C (302°F)	
ETFE	solid	50.63
	foamed	–
FEP	200°C (392°F)[b]	
	solid	50.70
	foamed	–
HDFRPE	75°C (167°F)	
LDFRPE	solid	50.133
	foamed	–
HDPE	75°C (167°F)	
	solid	50.136
	foamed	–
LDPE	75°C (167°F)	

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Table 13.1 Continued

Material(s)[a]	Temperature rating of insulation	Applicable table of physical properties in UL 1581 (see 13.2)
	solid foamed	50.136 –
PFA or MFA	200°C (392°F)[b] solid foamed 250°C (482°F)[b]	 50.137 – 50.137
Polypropylene: PP, FRPP (DP-3 series only)	75°C (167°F) solid foamed	 50.139 –
	60°C (140°F) solid foamed	 50.139 –
PTFE (TFE)	250°C (482°F)[b] solid expanded	 50.219 –
PVC	105°C (221°F) solid	 50.182
	90°C (194°F) solid	 50.182
	75°C (167°F) solid	 50.182
	60°C (140°F) solid	 50.182
SRPVC (semirigid PVC)	105°C (221°F) solid	 50.183
	90°C (194°F) solid	 50.183
	75°C (167°F) solid	 50.183
	60°C (140°F) solid	 50.183
PVDF AND PVDF copolymer	150°C (302°F) solid foamed	 50.185
	125°C (257°F) solid foamed	 50.185
Silicone rubber (DP-2 and -3 series only)	200°C (392°F) solid	 50.210
	150°C (302°F) solid	 50.210
TPE	105°C (221°F)	

Table 13.1 Continued on Next Page

Table 13.1 Continued

Material(s)[a]	Temperature rating of insulation	Applicable table of physical properties in UL 1581 (see 13.2)
	solid	50.225
	90°C (194°F) solid	50.225
XL: XLPE XPLVC XLEVA blends of these	105°C (221°F) solid	50.245
	90°C (194°F) solid	50.237
	75°C (167°F) solid foamed	50.241 –
XLPO	105°C (221°F) solid	50.233

[a] See 13.1.2 for the long-term evaluation of an insulation material not named in the first column or not complying with the short-term tests referenced in the last column.

[b] 150°C (302°F) is the limit for the cable temperature rating (see 8.3) where conductor strands are used that are smaller in diameter than 0.015 in or 0.38 mm and are uncoated or are coated with tin or a tin/lead alloy. The indicated rating higher than 150°C (302°F) applies where, regardless of diameter, the strands are coated with silver [200°C (392°F)] or nickel [250°C (482°F)]. See 5.1 and Table 8.1.

13.2 Properties

13.2.1 FLEXIBILITY TEST– The following insulations in place on the conductor shall not show any cracks on either the inside or outside surface after specimens are wound onto a mandrel of the diameter indicated in 13.2.2:

a) All foamed or expanded insulations with or without a skin.

b) All solid insulations with a skin that cannot be removed without damage to the insulation.

c) Aged specimens of 60°C (140°F) semirigid PVC solid insulation on Type DP-3 series cables. As indicated in note c to Table 50.185 of UL 1581, unaged specimens of this solid insulation are to be tested for tensile strength and elongation.

d) Aged specimens of PVDF and PVDF copolymer jackets and solid insulations. As indicated in note d to Table 50.185 of UL 1581, unaged specimens of these jackets and these solid insulations are to be tested for tensile strength and elongation.

13.2.2 The specimens that are to be aged are to be conditioned in a full-draft circulating-air oven for the length of time and at the temperature indicated for the jacket material, or for the insulation material adjacent to the conductor, in the applicable physical-properties table referenced in Table 13.1. When the insulation is foamed, the test conditioning is to be as specified for solid insulation of the same material. The conditioning is to be followed by 16 – 96 h of rest in still air at room temperature before the specimens are wound onto a mandrel. The aged specimens are to be wound at room temperature for six complete turns (adjacent turns touching) onto a circular mandrel having a diameter twice that of the diameter over the overall jacket, binder jacket, coaxial member jacket, or optical-fiber member jacket, or over the insulation (including any skin). Each specimen is to be unwound before being examined. Cracking on the inside surface can be detected as circumferential depressions in the outer surface of a specimen of material other than a fluoropolymer. Circumferential depressions in a fluoropolymer surface are likely to be yield marks (locally stronger points) rather than indicators of cracking.

13.2.3 PHYSICAL PROPERTIES TESTS – Specimens prepared from samples of solid insulations for which the flexibility test is not indicated shall have values of tensile strength and ultimate elongation that comply with the applicable table of physical properties referenced in Table 13.1. The samples are to be taken from the finished cable. The specimens are to be prepared from the samples and the testing is to be conducted as indicated in 13.2.4.

13.2.4 The methods of preparation of samples, of selection and conditioning of specimens, and of making the measurements and calculations for ultimate elongation and tensile strength shall be as indicated under the heading "Physical Properties of Insulation and Jacket" in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, with the modification that ECTFE and ETFE insulations with band-marking inks may have the ink removed before specimens are aged.

13.3 Thicknesses

13.3.1 The dimensions of the spacer (thread) portion of the material insulation in an air-gap coaxial member are not specified. The average thickness and the minimum thickness at any point of the tube portion of an air-gap coaxial member shall not be less than indicated in Table 13.4. The thicknesses of the integral insulation (solid) and jacket on a flat, parallel cable shall not be less than indicated in Table 13.5. The average thickness and the minimum thickness at any point of solid insulation (including any skin) in a coaxial member, and on every other conductor, including each conductor in jacketed ribbon cable before and after separation and in nonintegral flat cable, shall not be less than indicated in Table 13.2, Table 13.3, and Table 13.4. The thicknesses of foamed insulation (including any skin) shall be evaluated based on the performance of the finished cable when tested in accordance with this standard. In any case, the thicknesses of solid and foamed insulations (including any skin) are to be determined by means of measurements made as described in Section 250 of UL 1581, with the following modifications for stranded conductors that leave one or more strand impressions in the insulation that are too small to accommodate the smaller pin referred to in 250.11 of UL 1581, which is to be 0.0200 in (20.0 mils) or 0.508 mm in diameter:

a) The 0.003-in (3-mil) or 0.08-mm thickness-reduction allowance mentioned in 250.5 of UL 1581 is to be applied only to insulation that is from a stranded conductor as mentioned above and has an average thickness (including any skin) of at least 0.015 in or 0.38 mm.

b) Only an optical method as applicable from 13.3.2 and 13.3.3 is to be used for thickness measurements of insulation that is from a stranded conductor as mentioned above and has an average thickness (including any skin) less than 0.015 in or 0.38 mm.

13.3.2 Thickness measurements of a nylon or similar covering or of insulation having an average thickness or minimum thickness at any point of not more than 0.0060 in or 0.152 mm (including any skin) are to be made by means of a micrometer microscope or other optical instrument that is calibrated to read directly to at least 0.0001 in (0.1 mil) or 0.001 mm. Each of these measurements is to be recorded to the nearest 0.0001 in or 0.001 mm. Otherwise, under 13.3.1(b), a simply manipulated optical device that is accurate to 0.001 in (1 mil) or 0.01 mm may be used for insulation, with each measurement recorded to the nearest 0.001 in or 0.01 mm.

13.3.3 For 13.3.1(b), the conductor and any covering over the insulation or skin are to be removed from the finished insulated conductor, wire, or member. A thin slice of the insulation plus any skin is then to be cut perpendicular to the longitudinal axis of the resulting hollow tube. Measurements are to be taken of the maximum and minimum wall thicknesses of the slice. The recorded maximum and minimum thicknesses are to be added together and divided by 2 without any rounding off of the sum but with the resulting average rounded off (see 13.3.4 – 13.3.7) to the same degree as stated in 13.3.2 for the recorded measurements. The average thickness so determined and the recorded minimum thickness are to be taken as the average and minimum-at-any-point thicknesses that are to be compared with the applicable Table 13.2 – Table 13.5 or with whatever lesser thicknesses are established for the construction as the result of the insulation-crushing test described in Section 27.

13.3.4 ROUNDING OFF to the NEAREST 0.0001 inch – A figure in the fourth decimal place is to remain unchanged where the figure in the fifth decimal place is 0 – 4 and the figure in the fourth decimal place is odd or even, or where the figure in the fifth decimal place is 5 and the figure in the fourth decimal place is even (0, 2, 4, and so forth). A figure in the fourth decimal place is to be increased by 1 where the figure in the fifth decimal place is 6 – 9 and the figure in the fourth decimal place is odd or even, or where the figure in the fifth decimal place is 5 and the figure in the fourth decimal place is odd (1, 3, 5, and so forth).

13.3.5 ROUNDING OFF to the NEAREST 0.001 inch – A figure in the third decimal place is to remain unchanged where the figure in the fourth decimal place is 0 – 4 and the figure in the third decimal place is odd or even, or where the figure in the fourth decimal place is 5 and the figure in the third decimal place is even (0, 2, 4, and so forth). A figure in the third decimal place is to be increased by 1 where the figure in the fourth decimal place is 6 – 9 and the figure in the third decimal place is odd or even, or where the figure in the fourth decimal place is 5 and the figure in the third decimal place is odd (1, 3, 5, and so forth).

13.3.6 ROUNDING OFF to the NEAREST 0.001 mm – A figure in the third decimal place is to remain unchanged where the figure in the fourth decimal place is 0 – 4 and the figure in the third decimal place is odd or even, or where if the figure in the fourth decimal place is 5 and the figure in the third decimal place is even (0, 2, 4, and so forth). A figure in the third decimal place is to be increased by 1 where the figure in the fourth decimal place is 6 – 9 and the figure in the third decimal place is odd or even, or where the figure in the fourth decimal place is 5 and the figure in the third decimal place is odd (1, 3, 5, and so forth).

13.3.7 ROUNDING OFF to the NEAREST 0.01 mm – A figure in the second decimal place is to remain unchanged where the figure in the third decimal place is 0 – 4 and the figure in the second decimal place is odd or even, or where the figure in the third decimal place is 5 and the figure in the second decimal place is even (0, 2, 4, and so forth). A figure in the second decimal place is to be increased by 1 where the figure in the third decimal place is 6 – 9 and the figure in the second decimal place is odd or even, or where the figure in the third decimal place is 5 and the figure in the second decimal place is odd (1, 3, 5, and so forth).

Table 13.2
Minimum thicknesses of insulation in Type DP-1 series cables

Size of conductors	PVC, CP, TPE, XL, XLPO, SRPVC		ECTFE, ETFE, FEP, MFA, PFA, TFE, PVDF, PVDF copolymer		PVC under nylon jacket		
					PVC		Nylon
	Minimum average	Minimum at any point	Minimum average	Minimum at any point	Minimum average	Minimum at any point	Minimum at any point
	mils						
18 – 12 AWG	30	27	20	18	15	13	4
10	30	27	20	18	20	18	4
8	45	41	30	27	30	27	5
6	60	54	30	27	30	27	5
4 – 2	60	54	30	27	40	36	6
1 – 4/0	80	72	45	41	50	45	7
213 – 500 kcmil	95	86	–	–	60	54	8
501 – 1000	110	99	–	–	70	63	9
	mm						
18 – 12 AWG	0.76	0.69	0.51	0.46	0.38	0.33	0.10
10	0.76	0.69	0.51	0.46	0.51	0.46	0.10
8	1.14	1.04	0.76	0.69	0.76	0.69	0.13

Table 13.2 Continued on Next Page

Table 13.2 Continued

Size of conductors	PVC, CP, TPE, XL, XLPO, SRPVC		ECTFE, ETFE, FEP, MFA, PFA, TFE, PVDF, PVDF copolymer		PVC under nylon jacket		
					PVC		Nylon
	Minimum average	Minimum at any point	Minimum average	Minimum at any point	Minimum average	Minimum at any point	Minimum at any point
6	1.52	1.37	0.76	0.69	0.76	0.69	0.13
4 – 2	1.52	1.37	0.76	0.69	1.02	0.91	0.15
1 – 4/0	2.03	1.83	1.14	1.04	1.27	1.14	0.18
213 – 500 kcmil	2.41	2.18	–	–	1.52	1.37	0.20
501 – 1000	2.79	2.51	–	–	1.78	1.60	0.23

Table 13.3
Minimum thickness of insulation Type DP-2 series cables

AWG size of conductors	PVC, CP, TPE, XL, XLPO, PE, PP, and silicone		ECTFE, ETFE, FEP, MFA, PFA, TFE, PVDF, PVDF copolymer, and SRPVC		PVC with Nylon		
					PVC		Nylon
	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Minimum acceptable thickness at any point
	mils						
24 – 20	12	11	9	8	9	8	2
19 – 15	15	13	9	8	9	8	2
14 – 12	20	18	12	11	12	11	2
11 – 8	30	27	15	13	15	13	3
	mm						
24 – 20	0.30	0.28	0.23	0.20	0.23	0.20	0.05
19 – 15	0.38	0.33	0.23	0.20	0.23	0.20	0.05
14 – 12	0.51	0.46	0.30	0.28	0.30	0.28	0.05
11 – 8	0.76	0.69	0.38	0.33	0.38	0.33	0.08

Table 13.4
Minimum thickness of insulation Type DP-3 series cables

AWG size of conductors	PVC, LDPE, TPE, and XL LDFRPE		HDPE, HDFRPE ECTFE, ETFE, FEP, MFA, PFA, TFE, PVDF, PVDF copolymer, PP, XLPO, SRPVC		PVC with nylon		
	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Minimum acceptable average thickness	Minimum acceptable thickness at any point	Nylon
	mils						
30 – 10	6	5	5	4	5	4	2
	mm						
30 – 10	0.15	0.13	0.13	0.10	0.13	0.10	0.05

Table 13.5
Thickness of integral insulation (solid) and jacket on 2-, 3-, or 4- conductor flat, parallel DP-2 and DP-3 cables and distance between conductors

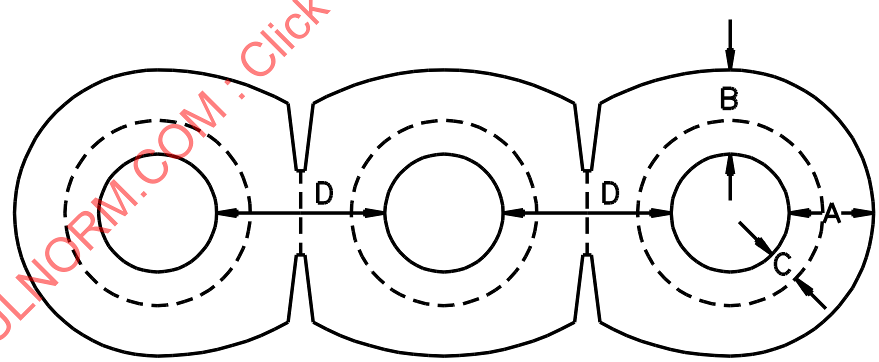
Cable types	Nominal thickness away from tear area(s) (vertical dashed line through web or webs in Figure 13.1) and outside point P or X (defined in Figure 13.2)		Minimum acceptable thickness at any point before separation measured outside point P or X (defined in Figure 13.2)		Minimum acceptable thickness at any point after separation		Minimum acceptable distance between copper conductors	
	A[a] (Information only – not a requirement)		B[a]		C[a]		D[a]	
	inch	mm	inch	mm	inch	mm	inch	mm
DP-2 Series								
24 – 12 AWG	0.030	0.76	0.027	0.69	0.013	0.33	0.047	1.19
11 – 8 AWG	0.045	1.14	0.040	1.02	0.027	0.69	0.080	2.03
DP-3 Series								
all sizes	0.020	0.51	0.018	0.46	0.010	0.25	0.030	0.76

[a] Dimension A – D are illustrated in Figure 13.1.

Figure 13.1

Integral flat cable

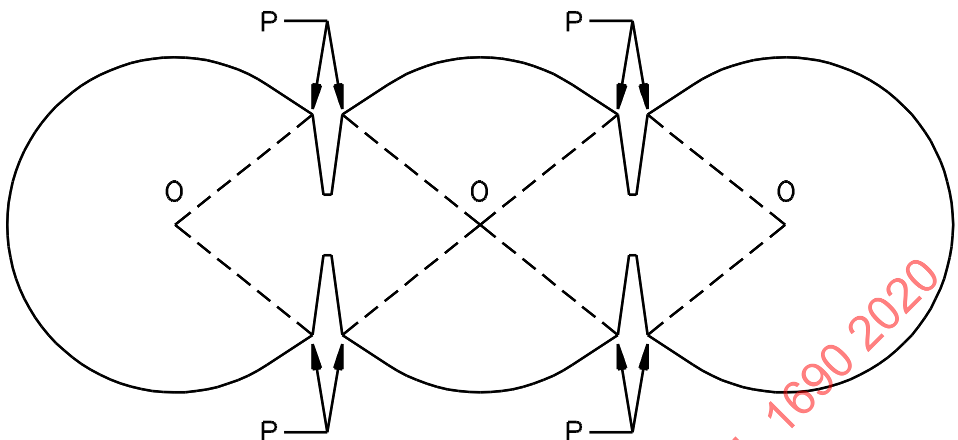
See Table 13.1 for dimensions A – D



SB0636-2

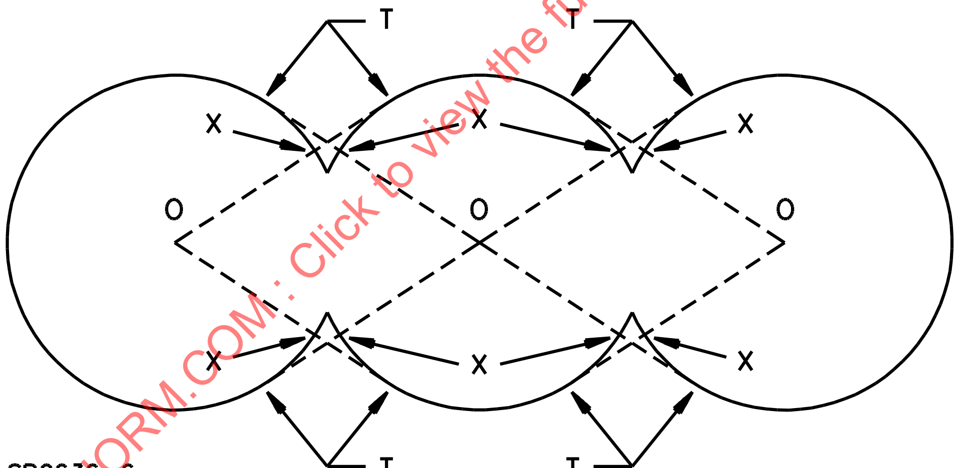
Figure 13.2

Definition of regions of valley slopes on which thickness measurements are not to be made in integral flat cables



SB0636–5

Constructions with a Cross Section Having a Definite Point P at the Outer End of Each Valley Slope OP in each case is a straight line from the center O of a conductor to P on the same segment of the cross section. Thickness measurements are not to be made on any valley slope.



SB0636–6

Constructions with a Cross Section not Having a Definite Point to Mark the Outer End of Each Valley Slope

OT in each case is a straight line from the center O of a conductor to T, the point of tangency, on the adjacent segment of the cross section. Thickness measurements are not to be made deeper on a valley slope than point X, which is the intersection of the line OT with the valley slope. Thickness measurements are to be made on each slope segment TX.

14 Optical-Fiber Member(s)

14.1 An optical-fiber member shall consist of either of the following:

a) One or more glass fibers that are individually coated and tight buffered and then are optionally jacketed in any thickness with one of the jacketing materials named in Table 16.1 or with another jacketing or insulating material whose applicability for the use is evaluated, or are optionally enclosed in a nonmetallic tape, wrap, or braid that provides complete coverage and is electrically nonconductive.

b) One or more glass fibers that are individually coated, optionally tight buffered, and then enclosed with or without a gel in a loose buffer tube. A loose buffer tube shall be of any thickness of one of the insulation or jacketing materials mentioned in (a), shall be optionally enclosed in a jacket of one of these materials in any thickness, or shall be optionally enclosed in a nonmetallic tape, wrap, or braid that provides complete coverage and is electrically nonconductive.

The construction of the glass fiber, of the coating, and of a tight buffer are not specified. The construction of a loose buffer tube that is covered by a jacket is not specified. The gel is not specified. The construction of a nonmetallic tape, wrap, or braid is not specified. Non-current-carrying metal or other electrically conductive parts may be included in an optical-fiber member but an optical-fiber member shall not have any electrical elements. An optical-fiber member may include one or more strength elements.

14.2 The energy that an optical-fiber cable carries in some laser systems presents a potential risk of eye or other injury to people. Consequently, where optical-fiber cables are installed in a laser system, the recommendations of the ANSI Z136 laser system safety standards should be applied. To help protect optical-fiber cable installers, users, service personnel, and anyone who handles the optical-fiber cable component of the system after installation, 35.1 specifies a tag, reel, or carton marking.

15 Assembly

15.1 Optical-fiber member(s)

15.1.1 Optical-fiber member(s) alone shall not constitute a cable. One or more optical-fiber members may be included in a cable. Optical-fiber members may be grouped with or without electrical conductors. Optical-fiber members in a cable shall be cabled alone or as a group with the same direction and with the same length of lay as the electrical conductors. In the performance of the cable, each optical-fiber member is to be considered as a filler. A group of optical-fiber members without any electrical conductor(s) in it may include one or more non-current-carrying metal parts (earth-grounded or interrupted when the hybrid cable is installed) such as a metal strength element or a metal vapor barrier. The construction of these parts is not specified. Each such part shall be physically and electrically isolated from any bare grounding conductor in the cable.

15.2 Circuit and grounding conductors

15.2.1 All of the circuit conductors and insulated grounding conductors shall have the same voltage rating. Insulated conductors with different temperature ratings may be mixed in a given cable if the cable is rated for the lowest temperature rating of any of the constituent insulated conductors.

15.2.2 One or more of the insulated conductors indicated in 5.1 shall be assembled in a cable. Sizes may be mixed within the indicated ranges. In a given cable, all of the power conductors shall be of the same metal. A cable may contain precabled groups of conductors as described in 15.2.4.

15.2.3 In a cable with two or more conductors, the conductors and any grounding conductor may be cabled (round cable – see 15.2.4) or laid parallel (flat cable).

15.2.4 The DP-1 or DP-2 circuit conductors in a round cable shall be cabled with a length of lay that is uniform throughout the length of the cable and is not greater than indicated in Table 15.1. Grouping of the circuit conductors into pairs, triads, quads, and other precabled subassemblies is not required but is acceptable if the length of lay of the conductors in each group and of the groups in the overall assembly comply with this paragraph and with Table 15.1. The direction of lay may be changed at intervals throughout the length of the cable. The intervals need not be uniform. In a cable in which the lay is reversed, each area in which the lay is right- or left-hand for several (typically 10) complete twists (full 360° cycles) shall have the insulated conductors or precabled groups of insulated conductors cabled with a length of lay that is not greater than indicated in Table 15.1, and 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 15.1. If the direction of lay is not reversed in a cable containing layers of conductors or groups, the direction of lay of successive layers is not specified.

15.2.5 The DP-3 conductors, wires, or members in any group or assembly shall be cabled but the length and direction of lay are not specified. Any group or assembly shall be essentially round. Preassemblies of two or more cabled conductors, wires, or members may be used in a group or assembly. A jacketed round cable consisting of 12 or fewer twisted pairs or 2, 3, or 4 single insulated conductors may have the pairs or insulated conductors laid straight but otherwise all conductors, groups of conductors, members, and groups of members shall not be laid straight. In any case, the length of lay is not specified. The direction of lay may be changed at intervals throughout the length of the cable.

Exception: Insulated conductors may be laid flat and parallel and bonded together or joined by a web of unspecified thickness to form a ribbon cable.

Table 15.1
Length of lay[a] of insulated conductors and precabled groups[b]

Number of insulated conductors in cable	Maximum acceptable length of lay
2	30 times conductor diameter[c]
3	35 times conductor diameter[c]
4	40 times conductor diameter[c]
5 or more	15 times the calculated diameter of the overall assembly but, in a multiple-layer cable, the length of lay of the conductors in each of the inner layers of the cable is not specified (governed by the construction of the cabling machine)

[a] These requirements do not apply to DP-3 and DP-3P cables.

[b] The length of lay of each conductor in a group shall comply with the tabulated value as if the group were a cable. Likewise, the length of lay of each group in a cable shall comply with the tabulated value as if each group was a conductor.

[c] "Conductor diameter" is the calculated diameter of the largest individual finished insulated conductor in the cable.

15.3 Fillers

15.3.1 Fillers may be provided in a cable to make the finished cable firm at all points. Fillers may be provided in a cable to make the finished cable round. In a round cable, fillers shall be cabled with the conductors or, if applicable to the construction, may be in the center of the cable. Fillers may be integral with or separate from any binder jacket or the overall cable jacket. If fillers are integral with a jacket, they and the jacket shall be readily separable from the underlying cable assembly. Fillers shall be of nonconductive nonmetallic material.

15.4 Binders

15.4.1 The entire cable assembly, or any group of conductors (with or without one or more optical-fiber members included in the group), or several such groups within the cable may be enclosed in a binder consisting of a shield (see 15.5.1 – 15.5.3) or of a braid, tape, or other unspecified means. An individual group or several groups may be enclosed in a thin binder jacket that is of the same material and temperature rating as the overall cable jacket.

15.5 Shield

15.5.1 A shield is not required but is acceptable over an individual insulated conductor, over one or several groups of conductors with or without one or more optical-fiber members in each group, or over the entire cable assembly. Several shields may be used in a given cable.

15.5.2 A shield shall consist of one of the following:

a) A polyester and metal laminated shield tape with or without a bare copper drain wire in electrical contact with the metal part of the tape. The drain wire shall be metal-coated if the tape metal is aluminum; otherwise, the drain wire may be metal-coated or uncoated. The drain wire may be under or over the tape.

b) A wrap or braid of metal-coated or uncoated copper wires.

c) A metal-coated or uncoated copper tape.

d) An evaluated equivalent of any of the above.

15.5.3 The details of the construction of a shield and the manner of its application are not specified but are to be judged on the basis of the performance of the finished cable in the tests described in this standard. There are no requirements for the electromagnetic performance of a shield.

16 Overall Jacket

16.1 Material and application

16.1.1 A jacket of one of the required or optional materials indicated in Table 16.1 shall be extruded directly over the flat or round assembly of conductors and any optical-fiber members, fillers, binders, and the like. The assembly shall be completely covered and well centered in the jacket. The jacket shall not have any defects (bubbles, open spots, rips, tears, cuts, or foreign material) that are visible with normal or corrected vision without magnification.

16.1.2 Cables on which a jacket thicker than indicated in Table 16.2 – Table 16.7 is necessary to enable the cable to comply with any applicable flame or other test described or referenced in these requirements shall be made with whatever greater thicknesses of jacket may be needed for this purpose. In this case, the minimum thickness at any point of the heavier jacket shall not be less than 80 percent of the average thickness of the heavier jacket.

a) For a cable in which the insulation is rated for 60 – 105°C (140 – 221°F), the jacket material shall have a temperature rating that is not more than 15°C (27°F) lower than the temperature rating of the insulation in the cable. The temperature rating of the cable is the same as the temperature rating of the insulation.

b) For a cable in which the insulation is rated for 125 – 250°C (257 – 482°F), the relationship between the temperature ratings of the insulation and the cable jacket is not specified but the temperature rating of the cable is that of whichever insulation or jacket in the cable has the lowest temperature rating.

16.2 Properties

16.2.1 Specimens prepared from samples of the overall jacket taken from the finished cable shall exhibit properties that comply with the applicable table referenced in Table 16.1 when tested as indicated in 16.2.2.

16.2.2 The methods of preparation of samples, of selection and conditioning of specimens, and of making the measurements and calculations for permanent set, ultimate elongation, and tensile strength shall be as indicated under the heading "Physical Properties Tests of Insulation and Jacket" in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, with the following modifications:

a) Jackets thinner than 0.018 in average and 0.014 in minimum at any point, or thinner than 0.46 mm average and 0.36 mm minimum at any point, are to be buffed only where necessary (natural indentations are not to be considered as imperfections).

b) Cables with an overall diameter not greater than 0.200 in or 5.1 mm may have their jackets tested as tubular specimens rather than as a die-cut specimens.

Table 16.1
Overall jacket

Material(s)[a]	Temperature rating of jacket	Applicable table of physical properties in UL 1581
CP	90°C (194°F)	50.1
	75°C (167°F)	50.1
Thermoplastic CPE	90°C (194°F)	50.28
Thermoset CPE	90°C (194°F)	50.29
	75°C (167°F)	50.30
ECTFE	150°C (302°F)	50.63
ETFE		
FEP	200°C (392°F)	50.70
HDFRPE, LDFRPE	75°C (167°F)	50.133
NBR/PVC	90°C (194°F)	50.83
	75°C (167°F)	50.80
Neoprene	90°C (194°F)	50.124
	75°C (167°F)	50.123
PFA or MFA	200°C (392°F)	50.137
	250°C (482°F)	50.137

Table 16.1 Continued on Next Page

Table 16.1 Continued

Material(s)[a]	Temperature rating of jacket	Applicable table of physical properties in UL 1581
PTFE	250°C (482°F)	50.219
TFE		
PVC	105°C (221°F)	50.182
	90°C (194°F)	50.182
	75°C (167°F)	50.182
	60°C (140°F)	50.182
PVDF and	150°C (302°F)	50.185
PVDF copolymer	125°C (257°F)	50.185
Silicone rubber	200°C (392°F)	50.210
(DP-3 only)	150°C (302°F)	50.210
TPE	105°C (221°F)	50.225
	90°C (194°F)	50.225
XL:	105°C (221°F)	50.245
XLPE	90°C (194°F)	50.237
XLPVC	75°C (167°F)	50.234
XLEVA		
blends of these		
XLPO	105°C (221°F)	50.233

[a] See 13.1.2 for the long-term evaluation of a jacket material not named in the first column or not complying with the short-term tests referenced in the last column.

16.3 Thicknesses

16.3.1 The average thickness and the minimum thickness at any point of the overall jacket shall not be less than indicated in Table 16.2 – Table 16.7 when measured as described in 13.3.2 and 13.3.3.

Table 16.2
Thickness[a] of overall non-fluoropolymer jacket on Types DP-1 and DP-1P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness		Minimum acceptable thickness at any point	
inches	mm	mils	mm	mils	mm
0 – 0.425	0 – 10.80	45	1.14	36	0.91
Over 0.425 but not over 0.700	Over 10.80 but not over 17.78	60	1.52	48	1.22

Table 16.2 Continued on Next Page

Table 16.2 Continued

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness		Minimum acceptable thickness at any point	
inches	mm	mils	mm	mils	mm
Over 0.700 but not over 1.500	Over 17.78 but not over 38.10	80	2.03	64	1.63
Over 1.500 but not over 2.500	Over 38.10 but not over 63.50	110	2.79	88	2.24

[a] A thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

Table 16.3
Thickness[a] of fluoropolymer jacket on Types DP-1 and DP-1P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness		Minimum acceptable thickness at any point	
inches	mm	mils	mm	mils	mm
0 – 0.700	0 – 17.78	30	0.76	24	0.61
Over 0.700 but not over 1.000	Over 17.78 but not over 25.40	45	1.14	36	0.91
Over 1.000 but not over 1.500	Over 25.40 but not over 38.10	60	1.52	48	1.22
Over 1.500 but not over 2.500	Over 38.10 but not over 63.50	80	2.03	64	1.63

[a] Thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

Table 16.4
Thickness[a] of non-fluoropolymer jacket on Types DP-2 and DP-2P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness		Minimum acceptable thickness at any point	
inches	mm	mils	mm	mils	mm
0 – 0.700	0 – 17.78	30	0.76	24	0.61
Over 0.700 but not over 1.000	Over 17.78 but not over 25.40	45	1.14	36	0.91
Over 1.000 but not over 1.500	Over 25.40 but not over 38.10	60	1.52	48	1.22
Over 1.500 but not over 2.500	Over 38.10 but not over 63.50	80	2.03	64	1.63

[a] A thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

Table 16.5
Thickness[a] of fluoropolymer jacket on Types DP-2 and DP-2P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness		Minimum acceptable thickness at any point	
inches	mm	mils	mm	mils	mm
0 – 0.700	0 – 17.78	20	0.51	16	0.41
Over 0.700 but not over 1.000	Over 17.78 but not over 25.40	30	0.76	24	0.61
Over 1.000 but not over 1.500	Over 25.40 but not over 38.10	45	1.14	36	0.91
Over 1.500 but not over 2.500	Over 38.10 but not over 63.50	60	1.52	48	1.22

[a] A thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

Table 16.6
Thicknesses[a] of nonintegral nonfluoropolymer cable jacket on Types DP-3 and DP-3P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket	Jacket whose tensile strength is less than 2500 lbf/in^2 or 17.21 MN/m^2 or 1724 N/cm^2 or 1.76 kgf/mm^2		Jacket whose tensile strength is at least 2500 lbf/in^2 or 17.21 MN/m^2 or 1724 N/cm^2 or 1.76 kgf/mm^2	
	Minimum acceptable average thickness of jacket	Minimum acceptable thickness at any point of jacket	Minimum acceptable average thickness of jacket	Minimum acceptable thickness at any point of jacket
inch				
0 – 0.400	0.025	0.020	0.018	0.014
Over 0.400 but not over 0.700	0.030	0.024	0.020	0.016
Over 0.700 but not over 1.500	0.045	0.036	0.030	0.024
mm				
0 – 10.16	0.64	0.51	0.46	0.36
Over 10.16 but not over 17.78	0.76	0.61	0.51	0.41
Over 17.78 but not over 38.10	1.14	0.91	0.76	0.61

[a] A thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

Table 16.7
Thicknesses[a] of nonintegral fluoropolymer cable jacket on Types DP-3 and DP-3P

Calculated diameter of round assembly under jacket or calculated equivalent diameter[b] of flat assembly under jacket		Minimum acceptable average thickness of jacket		Minimum acceptable thickness at any point of jacket	
inches	mm	inches	mm	inches	mm
0 – 0.250	0 – 6.35	0.008[c]	0.20[c]	0.006[c]	0.15[c]
Over 0.250 but not over 0.350	Over 6.35 but not over 8.89	0.010[c]	0.25[c]	0.008[c]	0.20[c]
Over 0.350 but not over 0.500	Over 8.89 but not over 12.70	0.013	0.33	0.010	0.25
Over 0.500 but not over 0.700	Over 12.70 but not over 17.78	0.015	0.38	0.012	0.30
Over 0.700 but not over 1.500	Over 17.78 but not over 38.10	0.020	0.51	0.016	0.41

[a] A thicker jacket may be required to enable the cable to comply with one or more tests. See 16.1.2.

[b] The equivalent diameter of a flat assembly is to be calculated as 1.1284 × $(TW)^{1/2}$, in which T is the thickness of the assembly and W is the width of the assembly.

[c] A jacket that is applied directly over the wire serving, wrap, or braid mentioned in 15.5.2(b) (no intervening wrap or other protective covering) shall be no thinner in average thickness than 0.013 in or 0.33 mm and shall not be thinner at any point than 0.010 in or 0.25 mm.

PERFORMANCE

17 Continuity Test of Conductors

17.1 The cable shall be tested for continuity of each conductor. The continuity testing is to be conducted in one of the following ways on 100 percent of production by the cable manufacturer at the cable factory:

a) The finished cable is to be tested on each master reel before the final rewind operation or as individual shipping lengths after the final rewind operation. A master reel is any reel containing a single length of finished cable that is intended to be cut into shorter lengths for shipping.

b) The assembled cable is to be tested before the overall covering is applied. In this case, one shipping length from each master reel of the finished cable is also to be tested. If any conductor in the finished cable in that length is found not to be continuous, 100 percent of the finished cable on the master reel from which the length was taken is to be tested.

17.2 To determine whether or not the finished cable complies with the requirement in 5.2, each conductor taken separately is to be connected in series with a light-emitting diode (LED), lamp, buzzer, bell, or other indicator, and an appropriate low-voltage a-c or d-c power supply.

18 Heat Shock Test

18.1 The insulation and any jacket of PVC, semirigid PVC, or TPE on, or in, Type DP-1 or 2 series cables shall not develop any cracks either on the inside or outside surface when the specimens described in 18.2 are tested as described in 18.3.

18.2 Specimens of each of the following are to be prepared from the finished cable:

a) Insulation representative of each conductor, wire, and coaxial member in the cable. In the case of a non-air-gap coaxial member, the member is to be tested as a whole after removal of the outer conductor and any overall jacket.

b) Integral insulation and jacket on flat cable.

c) Each individual jacket, binder jacket, cable jacket, and jacket over a metal covering in the cable (this includes the jackets on coaxial and optical-fiber members).

18.3 Each specimen is to be tightly wound for the number of turns indicated in Table 18.1 around a circular metal mandrel of the diameter indicated in Table 18.1. Adjacent turns are to touch one another, and each end of each specimen is to be held in place by a clamp or other secure means. The specimen/mandrel assemblies are to be suspended in a full-draft circulating-air oven for 60 min at the temperature indicated for the physical-properties testing of the insulation or jacket in Table 50.182 (PVC), 50.183 (semirigid PVC), or 50.224 (TPE) of UL 1581. No specimen is to touch anything other than the mandrel on which it is wound. At the end of the hour of heating, each specimen/mandrel assembly is to be removed from the oven and examined for cracks on the inside and outside surfaces immediately and again after cooling to room temperature in still air. Cracks on the inside surface can be detected from circumferential depressions in the outer surface of a specimen of material other than a fluoropolymer. Circumferential depressions in a fluoropolymer surface are likely to be yield marks (locally stronger points) rather than indicators of cracking.

Table 18.1
Heat-shock mandrel diameters and number of turns

Specimen	Calculated diameter over round specimen or calculated length of minor axis of ribbon or flat cable		Diameter of mandrel		Number of complete turns of specimen on mandrel
	inches	mm	inches	mm	
Nonintegral insulation	any	any	0.062	1.6	6
Integral insulation and Jacket	any	any	0.062	1.6	1
Central conductor and insulation from any coaxial member	any	any	2 times specimen diameter		6
Jacket other than over a metal covering	0 – 0.375	0 – 9.5	0.750	19.0	6
	Over 0.375 but not over 0.625	Over 9.5 but not over 15.9	1.625	41.3	6
	Over 0.625 but not over 1.000	Over 15.9 but not over 25.4	3.000	76.2	1
	Over 1.000 but not over 2.000	Over 25.4 but not over 50.8	3 times specimen diameter		1/2 (U bend)
	Over 2.000	Over 50.8	4 times specimen diameter		1/2 (U bend)
Jacket over a metal covering	any	any	5 times cable diameter		1/2 (U bend)

19 Deformation Test

19.1 The insulation and any jacket of solid FEP, solid FRPE, solid HDPE, solid LDPE, PVC, semirigid PVC, TPE, solid XL, or XLPO on or in Type DP-1 or -2 series cables shall not decrease more in thickness than indicated in Table 19.1 under the load indicated in Table 19.1 while being maintained at the temperature indicated in Table 19.1. The test is to be conducted as described in Section 560 of UL 1581 using test specimens described in 19.2 – 19.4.

19.2 The test is to be conducted using specimens prepared from samples of each of the following taken from the finished cable:

a) Insulation representative of each conductor, wire, and non-air-gap coaxial member in the cable. Specimens are to have solid conductors.

b) Integral insulation and jacket from flat cable.

c) Each individual jacket, binder jacket, cable jacket, and jacket over a metal covering in the cable (this includes the jackets on coaxial and optical-fiber members).

19.3 For any jacket that does not need to be tested in tubular form (see note a to Table 19.1), a rectangular specimen 1 in long and 9/16 in wide or 25 mm long and 14 mm wide is to be sliced and then buffed, or planed, split or skived to a uniform thickness of not more than 0.050 ±0.010 in or 1.27 ±0.25 mm, with both surfaces smooth.

19.4 The insulated conductors of a flat, parallel cable with integral insulation and jacket are to be separated. The insulation thickness T_1 of an insulated conductor from integral cable or of an individually insulated conductor or wire or of the center conductor of a non-air-gap coaxial member (any jacket is to be removed) or of a jacket that is to be tested in tubular form as described in note a to Table 19.1 is to be determined by the difference method from measurements made on a 1-in or 25-mm length of the insulated conductor from the finished cable.

Table 19.1
Deformation test specifications

Material, oven[c] temperature, maximum percent decrease	Specimens	Load[b] gf	Load[b] N
FEP	Rectangular jacket specimens (see 19.3	4000	39.23
121.0 ±1.0°C	Jacket specimens on inserts	a	a
(249.8 ±1.8°F)			
	Insulation on conductors (see 19.4):		
25 percent	12 – 20 AWG	800	7.85
	21 – 30 AWG	500	4.90
HDFRPE LDFRPE, HDPE, LDPE	Insulation on conductors (see 19.4):		
	12 – 20 AWG	400	3.92
	21 – 30 AWG	250	2.45
100.0 ±1.0°C			
(212.0 ±1.8°F)			
50 percent			
PVC	Rectangular jacket specimens (see 19.3)	2000	19.61
121.0 ±1.0°C	Jacket specimens on inserts	a	a
(249.8 ±1.8°F)			
	Insulation on conductors (see 19.4):		
50 percent	1/0 AWG – 1000 kcmil	2000	19.61
	1 – 6 AWG	1600	9.80
	7 – 10 AWG	500	4.90
	12 – 20 AWG	400	3.93
	21 – 30 AWG	250	2.45
SRPVC	Insulation on conductors (see 19.4):		
121.0 ±1.0°C	1/0 AWG – 1000 kcmil	2000	19.61
(249.8 ±1.8°F)	1 – 6 AWG	1600	9.80
50 percent	7 – 10 AWG	500	4.90

Table 19.1 Continued on Next Page

Table 19.1 Continued

Material, oven[c] temperature, maximum percent decrease	Specimens	Load[b]	
		gf	N
	12 – 20 AWG	400	3.93
	21 – 28 AWG	250	2.45
TPE	Rectangular jacket specimens (see 19.3)	2000	19.61
150.0 ±1.0°C	Jacket specimens on inserts	a	a
(302.0 ±1.8°F)			
	Insulation on conductors (see 19.4):		
50 percent	1/0 AWG – 1000 kcmil	2000	19.61
	1 – 6 AWG	1600	9.80
	7 – 10 AWG	500	4.90
	12 – 20 AWG	400	3.92
	21 – 30 AWG	250	2.45
XL, XLPO	Rectangular jacket specimens (see 19.3)	2000	19.61
121.0 ±1.0°C	Jacket specimens on inserts	a	a
(249.8 ±1.8°F)			
	Insulation on conductors (see 19.4):		
50 percent	1/0 AWG – 1000 kcmil	2000	19.61
	1 – 6 AWG	1600	9.80
	7 – 10 AWG	500	4.90
	12 – 20 AWG	400	3.93
	21 – 30 AWG	250	2.45

[a] A jacket is to be tested in tubular form where it is too small in diameter to yield flat specimens having a width equal to or exceeding 0.400 in or 10 mm. In this case, a solid steel rod or a solid conductor having a diameter that is neither too loose nor too tight in the jacket is to be inserted into the jacket. Using the nominal diameter in Table 20.1 of UL 1581, the diameter of the rod or conductor is to be converted to the equivalent conductor size and that size is to be used to determine the load from Table 19.1.

[b] The specified load is not the weight to be added to each rod in the test apparatus. The specified load is the total of the weight added and the weight of the individual rod. Because the weight of the rod varies from one apparatus to another and from one rod to another, specifying the exact weight to be added to a rod to achieve the specified load on a specimen is impractical in all cases except for an individual apparatus and rod.

[c] As stated in 560.6 of UL 1581, a full-draft circulating-air oven, a dead-air oven, or an internal-fan oven is to be used in this test.

20 Cold Bend Test of Insulation

20.1 After being conditioned for 4 h in circulating air that is precooled to and maintained at a temperature of -20.0° C, +3.0° C, -2.0° C (-4.0° F, +5.4° F, -3.6° F), the insulation or integral insulation and jacket on specimens removed from the finished cable (before being conditioned) shall not crack on the inside or outside surface when the specimens are individually wound onto a round mandrel in the cold chamber as described in 20.2 – 20.4.

20.2 A circular metal mandrel is to be used in this test. The diameter of the mandrel is to be as indicated in Table 20.1. The single mandrel is to be securely mounted in the chamber in a position that facilitates the winding.

20.3 For testing unjacketed ribbon cable or the integral insulation and jacket of flat cable, 24-in or 610-mm lengths of the complete ribbon or flat cable are to be used as flat specimens. The insulated conductors, wires, and any other coaxial members are to be removed from a 24-in or 610-mm length of other finished cable and are to be separated from one another and individually placed as round specimens in the precooled cold chamber. Any jacket and the shield(s) are to be removed from coaxial members before these members are placed in the cold chamber. The specimens and mandrel are to be conditioned for 4 h in circulating air that is precooled to and maintained at a temperature of -20.0°C, +3.0°C, -2.0°C (-4.0°F, +5.4°F, -3.6°F). At the end of the fourth hour, the specimens are to be wound individually, and in quick succession, for 6 full turns onto the mandrel, with adjacent turns touching (1 complete turn is to be used for flat cable). The winding of each specimen is to be at an approximately uniform rate of 5 seconds per turn. The winding is to be done in the cold chamber.

20.4 With a minimum of handling and while remaining in the coiled form, each specimen is to be slid from the mandrel, removed from the test chamber, and placed on a horizontal surface. The specimens are to rest on that surface undisturbed for at least 60 min in still air to warm at a room temperature of 24.0 ±8.0°C (75.2 ±14.4°F). Each specimen is then to be examined for cracking on the inside and outside surfaces of the insulation or of the integral insulation and jacket. Cracks on the inside surface can be detected as circumferential depressions in the outer surface of a specimen of material other than a fluoropolymer. Circumferential depressions in a fluoropolymer surface are likely to be yield marks (locally stronger points) rather than indicators of cracking.

Table 20.1
Cold bend mandrel diameter

Calculated diameter over round specimen or calculated length of minor axis of ribbon or flat cable		Diameter of mandrel	
inch	mm	inch	mm
0 – 0.045	0 – 1.14	0.125	3.18
Over 0.045 but not over 0.062	Over 1.14 but not over 1.58	0.188	4.78
Over 0.062 but not over 0.083	Over 1.58 but not over 2.11	0.250	6.35
Over 0.083 but not over 0.104	Over 2.11 but not over 2.64	0.313	7.95
Over 0.104 but not over 0.125	Over 2.64 but not over 3.18	0.375	9.53
Over 0.125 but not over 0.146	Over 3.18 but not over 3.71	0.438	11.1
Over 0.146 but not over 0.167	Over 3.71 but not over 4.24	0.500	12.7
Over 0.167 but not over 0.188	Over 4.24 but not over 4.78	0.563	14.3
Over 0.188 but not over 0.208	Over 4.78 but not over 5.28	0.625	15.9
Over 0.208 but not over 0.229	Over 5.28 but not over 5.82	0.688	17.5
Over 0.229 but not over 0.250	Over 5.82 but not over 6.35	0.750	19.1
Over 0.250 but not over 0.271	Over 6.35 but not over 6.88	0.813	20.7
Over 0.271 but not over 0.292	Over 6.88 but not over 7.42	0.875	22.2
Over 0.292 but not over 0.333	Over 7.42 but not over 8.46	1.000	25.4

21 Cold Bend Test of Complete Cable

21.1 After being conditioned for 4 h in circulating air that is precooled to and maintained at a temperature of −20.0° C, +3.0° C, −2.0° C (−4.0° F, +5.4° F, −3.6° F), specimens of the complete cable shall not be damaged when the specimens are individually wound onto a round mandrel as described in 21.2 and 21.3.

21.2 Four straight test lengths of the complete finished cable are to be cooled for 4 h in circulating air that is precooled to and maintained at a temperature of −20.0°C, +3.0°C, −2.0°C (−4.0°F, +5.4°F, −3.6°F). At the end of the fourth hour, the specimens are to be removed from the cold chamber one at a time and are to be wound individually for 3 full turns around a circular wooden mandrel of a diameter equal to 8 times the calculated diameter or length of minor axis of the outside of a cable that does not contain any shield, or equal to 12 times the calculated diameter or length of minor axis of the outside of a cable that contains one or more shields (coaxial members are included here). There is not to be any more tension applied to a specimen than is necessary to keep the surface of the specimen in contact with the mandrel. Adjacent turns are to touch one another. The winding of each specimen is to be conducted at an approximately uniform rate of 5 seconds per turn, and the time taken to remove a specimen from the cold chamber and complete the winding is not to exceed 30 s. As an alternative, the test may be performed in the cold chamber using wood or metal mandrels.

21.3 With a minimum of handling and while remaining in the coiled form, each specimen is to be slid from the mandrel and placed on a horizontal surface. The specimens are to rest on the surface undisturbed for at least 4 h in still air to warm at a room temperature of 24.0 ±8.0°C (75.2 ±14.4°F) before being examined for surface damage. Each specimen is then to be disassembled and examined further for damage. The cable is acceptable if, for the first length tested, there aren't any cracks, splits, tears, or other openings in any part of the cable. Cracking on the inside surface of a jacket or of the insulation can be detected as circumferential depressions in the outer surface of a jacket or insulation of material other than a fluoropolymer. Circumferential depressions in a fluoropolymer surface are likely to be yield marks (locally stronger points) rather than indicators of cracking. If the first test length has any of these faults, acceptance is to be governed by the results obtained from the three remaining test lengths. The cable is not acceptable if any of the three additional test lengths have one or more faults. The examinations are to be made with normal or corrected vision without magnification.

22 Spark and Dielectric Withstand Test Alternatives for Type DP-3 Series Cables

22.1 The insulation on each conductor for and in every length of integral Type DP-3 and DP-3P cables shall comply with a spark test without faults. The insulation on each conductor for and in every length of nonintegral Type DP-3 and DP-3P cables shall comply with a spark test without faults or a dielectric withstand test. One hundred percent of production is to be tested by the manufacturer at the factory. Within a factory, different alternatives may be chosen for different sizes of the same construction.

22.2 The spark test indicated in 22.1 is to be a d-c spark test of 2500 V or an rms a-c spark test of 1750 V on each insulated conductor before the conductor is assembled into the cable or, if applicable, on each twisted pair after pairing and before the pair is assembled into the cable. No faults are acceptable. The test equipment and method are to be as described in Spark Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits, Section 910 of UL 1581.

22.3 The dielectric withstand test indicated as an option for nonintegral cable in 22.1 is to be an rms a-c dielectric withstand test of at least 2 s at 900 V on the finished cable or a d-c dielectric withstand test of at least 2 s at 1250 V on the finished cable. The test potential is to be applied as follows and the test equipment and method are to be as described in Dielectric Voltage-Withstand Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits, Section 830 of UL 1581:

a) COAXIAL CABLE and a SINGLE, SHIELDED, INSULATED CONDUCTOR – Conductor to shield, with the shield connected to earth ground.

b) CABLE without ANY SHIELD or METAL COVERING, CABLE with a SHIELD or METAL COVERING over the ENTIRE CONDUCTOR ASSEMBLY, and ANY SHIELDED GROUP of TWO or MORE INDIVIDUALLY INSULATED CONDUCTORS within the CABLE – Successively between each conductor and all other conductors connected together, to any shield (s) and/or metal covering, and to earth ground.

The equipment is to apply the test potential automatically for each 2-s test. The test potential may be applied manually for tests longer than 2 s. In all cases, the full test potential is to be applied throughout the test interval that is chosen by the cable manufacturer.

23 Spark Test after Insulating for Type DP-1 and DP-2 Series Cables

23.1 The insulation on each conductor, wire, and coaxial member for and in every length of Type DP-1 and DP-2 cables shall comply with a spark test. One hundred percent of production shall be tested by the manufacturer at the factory. No faults are acceptable.

23.2 The spark test indicated in 23.1 is to be at the voltage shown in Table 23.1 on each conductor, wire, and coaxial member after it is insulated and before any subsequent operation. The test equipment and method are to be as described in Spark Test, Method, Section 900 of UL 1581.

Table 23.1
RMS test potentials for Type DP-1 and DP-2 cables

Cable	Voltage-withstand test potential in kilovolts[a]	Spark test potential in kilovolts
Type DP-2:		
insulations not over 15 mils or 0.38 mm in average thickness	1.5	3
insulations not over 30 mils or 0.76 mm in average thickness	1.5	5
insulations not over 30 mils or 0.76 mm in average thickness	1.5	6
Type DP-1:		
insulations not over 30 mils or 0.76 mm in average thickness	2	6
insulations not over 45 mils or 1.14 mm in average thickness	3	7
insulations not over 60 mils or 1.52 mm in average thickness	4	10
insulations not over 80 mils or 2.03 mm in average thickness	4	12.5
insulations not over 95 mils or 2.18 mm in average thickness	5	14.5
insulations not over 110 mils or 2.51 mm in average thickness	6	16.5

[a] For routine production dielectric voltage-withstand testing, the time of application of the test potential is to be 15 s or 60 s.

24 Dielectric Voltage-Withstand Test for Type DP-1 and DP-2 Series Cables

24.1 The insulation on each conductor, wire, and coaxial member in every length of finished cable shall withstand without breakdown a 48 – 62 Hz essentially sinusoidal rms test potential as shown in Table 23.1 applied for 1 min. In the case of a coaxial member or a single, shielded, insulated conductor, the test potential shall be applied between the conductor and the shield, with the shield connected to earth ground. In all other cases, the test potential shall be applied between each conductor taken separately and all other conductors and any shield(s) and/or metal covering connected together and to earth ground. The test equipment and method are to be as described in Dielectric Voltage-Withstand Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits, Section 830 of UL 1581. This test is required on 100 percent of production of shielded cables.

25 Insulation Resistance Test at 60.0°F (15.6°C)

25.1 The insulation on each conductor, wire, and coaxial member in a Type DP cable shall exhibit an insulation resistance at 60.0°F (15.6°C) of not less than 100 MΩ based on 1000 conductor ft, or not less than 30.5 MΩ based on a conductor kilometer, when the cable is tested as described in 25.2 – 25.8.

25.2 The insulation-resistance test is not a routine production test at the factory. It is to be conducted as a routine part of the factory-inspection follow-up work.

25.3 The measuring equipment and test procedure shall be applicable but otherwise are not specified. A megohm bridge used for these measurements shall be of applicable range and calibration, shall present readings that are accurate to 10 percent or less of the value indicated by the meter, and shall have a 100 – 550-V or higher open-circuit potential.

25.4 Coaxial cable is to be tested dry with the insulation-resistance readings made between the center and outer conductors on specimens that are at least 50 ft or 15 m long. Flat, parallel cable and individually insulated conductors (any nylon or similar covering is to be in place) and wires are to be immersed in tap water for at least 6 h at room temperature before the insulation-resistance reading is taken. The immersion vessel is to have an electrode for grounding the water to the earth (this may be the inside surface of a metal tank if that surface is not painted or otherwise insulated from the water). For the test in water, the immersed length of each specimen is to be at least 50 ft or 15 m, and at least 2.5 ft or 750 mm at each end of each specimen is to extend out of the water and is to be kept dry as leakage insulation.

25.5 If at the time of immersion the temperature of any part of the coil or reel of finished cable differs by more than 5.0°F (2.8°C) from the temperature of the water, one of the following is to be done to make certain that the water, the insulation, and the conductor or wire are at the same temperature at the time that the insulation resistance is measured:

a) The insulation and the conductor or wire are to be considered to be at the same temperature as the water in which they are immersed whenever the same d-c resistance of the conductor is obtained in each of three successive measurements made at intervals of 30 min by means of a Kelvin-bridge ohmmeter that presents readings accurate to 2 percent or less of the value indicated by the meter.

b) The water is to be heated or cooled, as necessary, to within 5.0°F (2.8°C) of the temperature of the insulation and conductor or wire before the coil or reel is immersed.

25.6 The water and the entire length of the immersed insulated conductor, nylon or similarly covered insulated conductor, insulated wire, or flat cable are to be at any one temperature in the range of 40.0 – 95.0°F (4.4 – 35.0°C) at the time that the insulation resistance is measured. If their temperature at this time is other than 60.0°F (15.6°C), the resulting insulation resistance is to be multiplied by the applicable factor M indicated in Table 25.1.

25.7 A test at 60.0°F (15.6°C) is to be made for a coil or reel that does not show acceptable results when the water temperature is other than 60.0°F (15.6°C).

25.8 If coils or reels are connected together for the insulation-resistance test and acceptable results are not obtained, the individual coils or reels are to be retested to determine which ones have at least the required insulation resistance.

Table 25.1
Multiplying factor M[a] for adjusting insulation resistance to 60.0°F (15.6°C) from another room temperature

Temperature		M[a]				
		CP, XL, and XLPO	PVC[b] and semirigid PVC[b]			
°F	°C		I	II	III	IV
40	4.4	0.53	0.12	0.17	0.21	0.31
41	5.0	0.55	0.13	0.19	0.23	0.33
42	5.6	0.57	0.15	0.21	0.25	0.35
43	6.1	0.59	0.16	0.22	0.27	0.37
44	6.7	0.60	0.18	0.25	0.29	0.39
45	7.2	0.62	0.20	0.27	0.31	0.42
46	7.8	0.64	0.23	0.29	0.34	0.44
47	8.3	0.66	0.25	0.32	0.36	0.47
48	8.9	0.68	0.28	0.35	0.39	0.49
49	9.4	0.70	0.31	0.38	0.43	0.53
50	10.0	0.73	0.35	0.42	0.46	0.56
51	10.6	0.76	0.39	0.46	0.50	0.59
52	11.1	0.78	0.43	0.50	0.54	0.63
53	11.7	0.80	0.48	0.55	0.58	0.67
54	12.2	0.83	0.54	0.60	0.63	0.70
55	12.8	0.86	0.60	0.65	0.68	0.75
56	13.3	0.88	0.66	0.71	0.74	0.79
57	13.9	0.91	0.73	0.78	0.80	0.84
58	14.4	0.94	0.82	0.85	0.86	0.90
59	15.0	0.97	0.90	0.92	0.93	0.95
60	15.6	1.00	1.00	1.00	1.00	1.00
61	16.1	1.03	1.11	1.09	1.08	1.06
62	16.7	1.07	1.24	1.19	1.17	1.13
63	17.2	1.10	1.38	1.30	1.26	1.19
64	17.8	1.13	1.53	1.41	1.36	1.26
65	18.3	1.17	1.70	1.54	1.47	1.34
66	18.9	1.20	1.88	1.69	1.59	1.42
67	19.4	1.24	2.09	1.84	1.72	1.51
68	20.0	1.28	2.31	1.99	1.85	1.60
69	20.6	1.32	2.57	2.18	2.00	1.69
70	21.1	1.36	2.85	2.38	2.17	1.79
71	21.7	1.40	3.17	2.59	2.34	1.90
72	22.2	1.45	3.52	2.82	2.53	2.02
73	22.8	1.50	3.90	3.08	2.72	2.14
74	23.3	1.55	4.31	3.35	2.94	2.27
75	23.9	1.59	4.78	3.65	3.18	2.40
76	24.4	1.64	5.30	3.98	3.43	2.54
77	25.0	1.69	5.88	4.34	3.70	2.70
78	25.6	1.75	6.51	4.73	4.00	2.86
79	26.1	1.80	7.27	5.16	4.33	3.03
80	26.7	1.86	8.07	5.61	4.67	3.21

Table 25.1 Continued on Next Page