UL 2250

Underwriters Laboratories Inc.

Standard for Safety

Instrumentation Tray Cable

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UL Standard for Safety for Instrumentation Tray Cable, UL 2250

Second Edition, Dated April 3, 2006

SUMMARY OF TOPICS

Revision pages have been issued for the Standard for Instrumentation Tray Cable, UL 2250, to reflect the latest ANSI approval date and to incorporate the proposal dated August 14, 2009. This proposal includes the following:

- ***Addition of requirements for voice communications conductors.***

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. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated August 14, 2009.

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UL 2250

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First Edition – December, 1996

Second Edition

April 3, 2006

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through November 3, 2009.

The most recent designation of ANSI/UL 2250 as an American National Standard (ANSI) occurred on November 3, 2009. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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 http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover Type ITC instrumentation control cables consisting of two or more current-carrying copper or thermocouple alloy conductors with or without either or both:

a) Grounding conductor(s), bare or insulated, and

b) 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) on circuits rated 150 V or less and 5 A or less in accordance with Article 727 and other applicable parts of the National Electrical Code (NEC).

1.2 These cables are rated 300 V but are not so marked. Cables for direct-burial are so marked. Jacketed Type ITC cables comply with one of the following 70,000 Btu/h (20.5 kW) vertical-tray flame tests:

a) The UL test referenced in 35.2.1 – 35.2.2 of these requirements. These paragraphs apply 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.

b) The FT4/IEEE 1202 test referenced in 35.3.1 of these requirements. This paragraph applies the test method described as the FT4/IEEE 1202 Type of Flame Exposure (smoke measurements are not applicable) in UL 1685.

c) For limited-smoke cable, either the UL test or the FT4/IEEE 1202 test referenced in 35.4.1 and 35.4.2 of these requirements. These paragraphs apply the test methods described in UL 1685 with smoke measurements included.

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 14.3) to carrying optical energy that has been ruled not hazardous to the human body.

1.4 All Type ITC cables qualify for exposure to sunlight (a 720-hour sunlight-resistance test is required – see 29.1). A marking is not required; however, where used, the marking consists of ″sun res″ or ″sunlight resistant″ on the tag and either on the overall cable jacket or legible through the jacket [see 42.1 (i)].

1.5 These cables may have a metal sheath or armor over the required non/metallic jacket.

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

1.7 The overall jacket on Type ITC cable is a ″gas/vapor-tight continuous sheath″ in the sense discussed in Sections 501.5 (D) and 501.5 (E) of the National Electrical Code, ANSI/NFPA 70, (see 16.1.1).

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1.8 Cables that are surface marked ″-ER″ are for use as exposed runs of not more than 50 ft (15.2 m) between a cable tray and equipment where the cables are supported and secured every 6 ft (1.8 m).

1.8 effective October 3, 2006

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.

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 Instrumentation tray cable shall comply in all respects with the applicable requirements for construction details, test performance, and markings.

5 Conductors

5.1 The conductors shall be of soft-annealed copper or thermocouple alloy. Soft-annealed copper shall comply with ASTM B 3. A metal coating that is provided on soft-annealed copper, 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 298 or of another metal or alloy (evaluation required). Thermocouple alloys are not specified.

5.2 Each conductor shall be continuous throughout the entire length of the finished cable – see test in 19.1 and 19.2.

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6 Size, Temper, and Assembly

6.1 Conductors shall be solid or stranded 22 – 12 AWG copper or solid size 22 – 12 AWG thermocouple alloy. The sizes of thermocouple-extension wire are nominal and are intended only for use in the cable marking that is described in 42.1(g). The conductor in a thermocouple-extension wire is not required to comply with a diameter or resistance value.

7 Conductor Diameter and Cross-Sectional Area

7.1 The diameter of a solid conductor shall not be smaller than indicated in Table 20.1 of UL 1581 when determined as described in 200.1 and 200.2 of UL 1581. The cross-sectional area of a stranded conductor shall not be smaller than indicated in the 0.98X nominal column Table 20.1 of UL 1581 when determined as required in 7.2.

7.2 The cross-sectional area of a stranded conductor is to be determined either:

a) As the sum of the areas of its component strands, or

b) By the weight method outlined in 210.1 – 210.4 of UL 1581.

8 Metal Coating

8.1 If the insulation adjacent to a 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 Use of a metal coating is not specified on a solid conductor or the individual wires (strands) of a stranded conductor on which a metal coating is not required for corrosion protection.

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 15.5.2(b). 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.

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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 in or 0.38 mm	At least 0.015 in 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)	Over 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 is to be made by separately joining each individual wire, or is to be made 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). The insulation applied to joints after insulating shall be equivalent to that removed and shall comply with the requirements in this Standard.

11 Resistance

11.1 The direct-current resistance of any length of conductor shall not be higher than the maximum acceptable (nominal x 1.02) indicated in the applicable one of the eleven Tables 30.1 – 30.5, 30.5A, and 30.6 – 30.10 of UL 1581 at 20°C (68°F) or at 25°C (77°F) or in Table 11.1 or 11.2 of this Standard when measured as described in 220.1 – 220.9 of UL 1581.

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Table 11.1
Maximum direct-current resistance of solid copper conductors

AWG size of conductor	Uncoated				Coated			
	20°C		25°C		20°C		25°C	
	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km
22	16.5	54.1	16.8	55.1	17.2	56.4	17.5	57.4
21	13.1	43.0	13.3	43.6	13.6	44.6	13.8	45.3
20	10.3	33.8	10.5	34.5	10.7	35.1	10.9	35.8
19	8.21	26.9	8.37	27.4	8.54	28.0	8.70	28.5
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
14	2.57	8.45	2.62	8.61	2.68	8.78	2.72	8.96
13	2.04	6.69	2.08	6.82	2.12	6.96	2.16	7.09
12	1.62	5.31	1.65	5.42	1.68	5.53	1.71	5.64

Table 11.2
Maximum direct-current resistance of stranded copper conductors

AWG size of conductors	Uncoated				Coated			
	20°C		25°C		20°C		25°C	
	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km	Ω/1000 feet	Ω/km
22	16.9	55.4	17.2	56.4	17.5	57.4	17.9	58.7
21	13.3	43.6	13.6	44.6	13.9	45.6	14.1	46.3
20	10.5	34.4	10.7	33.1	10.9	35.8	11.1	36.4
19	8.39	27.5	8.66	28.4	8.71	28.6	8.87	29.1
18	6.66	21.9	6.79	22.3	6.92	22.7	7.0	23.1
17	5.29	17.4	5.40	17.7	5.47	17.9	5.59	18.3
16	4.19	13.7	4.27	14.0	4.35	14.3	4.44	14.6
15	3.30	10.8	3.37	11.1	3.44	11.3	3.50	11.5
14	2.62	8.60	2.67	8.76	2.73	8.96	2.77	9.09
13	2.08	6.82	2.12	6.96	2.16	7.09	2.20	7.22
12	1.65	5.41	1.68	5.51	1.17	5.61	1.74	5.71

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12 Stranding

12.1 A stranded wire or cable shall have a minimum of seven strands. The length of lay of the strands shall be a maximum of 20 times the diameter of the conductor for 19 – 12 AWG conductors and shall be a maximum of 25 times the diameter of the conductor for 22– 20 AWG conductors. The direction of the lay shall be left-hand.

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.

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, Table 13.2, or referenced in note a to Table 13.1. The insulation shall be solid. 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. 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.

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, Table 13.2, 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 the temperature rating for the cable determined as specified in 16.1.2. The thicknesses of insulation and/or jacket using materials (a) and/or (b) shall be as required for the cable. 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.

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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) 75°C (167°F)	50.1 50.1
ECTFE ETFE	150°C (302°F)	50.63
FEP	200°C (392°F)[b]	50.70
HDFRPE LDFRPE	75°C (167°F)	50.133
HDPE	75°C (167°F)	50.136
LDPE	75°C (167°F)	50.136
PFA MFA	200°C (392°F)[b] 250°C (482°F)[b]	50.137 50.137
Polypropylene: PP, FRPP	75°C (167°F) 60°C (140°F)	50.139 50.139
PTFE TFE	250°C (482°F)[b]	50.219
PVC	105°C (221°F) 90°C (194°F) 75°C (167°F) 60°C (140°F)	50.182 50.182 50.182 50.182
SRPVC (semirigid PVC)	105°C (221°F) 90°C (194°F) 75°C (167°F) 60°C (140°F)	50.183 50.183 50.183 50.183
PVDF and PVDF copolymer	150°C (302°F) 125°C (257°F)	50.185 50.185
Silicone rubber	200°C (392°F) 150°C (302°F)	50.210 50.210
TPE	105°C (221°F) 90°C (194°F)	50.223 50.224
XL: XLPE XLPVC XLEVA blends of these	 105°C (221°F) 90°C (194°F) 75°C (167°F)	 50.245 50.237 50.241
XLPO	105°C (221°F)	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)].

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Table 13.2
Physical properties 200°C (392°F) and 150°C (302°F) silicone insulation[a] suitable for use without a braid or covering

Temperature rating of insulation	Condition of specimens at time of measurement	Minimum ultimate elongation (1-in or 25-mm bench marks)	Minimum tensile strength
150°C (302°F) or 200°C (392°F)	Unaged	250 percent (2.5 in or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa (MN/m^2) or 827 N/cm^2 or 0.844 kgf/mm^2
150°C (302°F)	Aged in a full-draft circulating-air oven for 60 d at 158.0±1.0°C (316.4±1.8°F)	150 percent (1.5 in or 37.5 mm) or 25 percent of the result with unaged specimens	850 lbf/in^2 or 5.86 MPa (MN/m^2) or 586 N/cm^2 or 0.598 kgf/mm^2 or 60 percent of the result with unaged specimens
200°C (392°F)	Aged in a full-draft circulating-air oven for 60 d at 210 ±1.0°C (410.0 ±1.8°F)	100 percent (1 in or 25 mm) or 25 percent of the result with unaged specimens	600 lbf/in^2 or 4.14 MPa (MN/m^2) or 414 N/cm^2 or 0.422 kgf/mm^2 or 60 percent of the result with unaged specimens

[a] Silicone rubber designates a thermoset compound whose characteristic constituent is poly-organo-siloxane.

13.2 Properties

13.2.1 The following jackets and insulations in place on the conductor shall not show any cracks on either the inside or outside surface after specimens are tested in accordance with 20.2.1:

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

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

13.2.2 PHYSICAL PROPERTIES TESTS – Specimens prepared from samples of 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 13.2.3.

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13.2.3 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 average thickness and the minimum thickness at any point of insulation (including any skin) in a coaxial member, and on every other conductor, before and after separation and in nonintegral flat cable, shall not be less than indicated in Table 13.3. The thicknesses of insulations (including any skin) are to be determined by means of measurements made as described in Thicknesses of Insulation on Flexible Cord and on Fixture Wire, 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.

Table 13.3
Minimum thickness of insulation

AWG size of conductors	PVC, CP, TPE, XL, XLPO, PE[a], PP, FRPP, and silicone rubber		ECTFE, ETFE, FEP, MFA, PFA, PTFE, TFE, PVDF, PVDF copolymer, and SRPVC		PVC with nylon jacket		
					PVC		Nylon
	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point	Minimum thickness at any point
	mils						
22 – 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
	mm						
22 – 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

[a] Includes HDPE, LDPE, HDFRPE, and LDFRPE.

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.

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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 13.3.

13.3.4 ROUNDING OFF to the NEAREST 0.0001 in – A figure in the fourth decimal place is to remain unchanged if the figure in the fifth decimal place is:

a) 0 – 4 and the figure in the fourth decimal place is odd or even, or

b) 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 if the figure in the fifth decimal place is:

c) 6 – 9 and the figure in the fourth decimal place is odd or even, or

d) 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 in – A figure in the third decimal place is to remain unchanged if the figure in the fourth decimal place is:

a) 0 – 4 and the figure in the third decimal place is odd or even, or

b) 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 if the figure in the fourth decimal place is:

c) 6 – 9 and the figure in the third decimal place is odd or even, or

d) 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 if the figure in the fourth decimal place is:

a) 0 – 4 and the figure in the third decimal place is odd or even, or

b) 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 if the figure in the fourth decimal place is:

c) 6 – 9 and the figure in the third decimal place is odd or even, or

d) 5 and the figure in the third decimal place is odd (1, 3, 5, and so forth).

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13.3.7 ROUNDING OFF to the NEAREST 0.01 mm– A figure in the second decimal place is to remain unchanged if the figure in the third decimal place is:

a) 0 – 4 and the figure in the second decimal place is odd or even, or

b) 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 if the figure in the third decimal place is:

c) 6 – 9 and the figure in the second decimal place is odd or even, or

d) 5 and the figure in the second decimal place is odd (1, 3, 5, and so forth).

13.4 Individual covering

13.4.1 Silicone insulation that complies with the requirements in Table 13.1 shall have a braid covering or a covering of nylon. A covering is not required over a silicone insulation that conforms to the requirements in Table 13.2.

13.4.2 The thicknesses at any point of a required or optional nylon or similar covering shall not be less than 0.002 in or 0.05 mm when measured as described in Thicknesses of Jacket on Flexible Cord, Fixture Wire, and Elevator Cable, Section 280, of the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

14 Optical-Fiber Member(s)

14.1 Each optical-fiber member shall consist of one of the following and shall be separated from the rest of the cable by material that is electrically nonconductive (an insulation grade is not required):

a) One or more glass fibers that are individually coated and tight buffered and then are covered by a nonmetallic tape, wrap, or braid (complete coverage is required) or by a jacket. Except that the covering shall be electrically nonconductive, the materials, thickness, and other features of these elements are not specified.

b) One or more glass fibers that are individually coated, are or are not tight buffered, are enclosed with or without a gel in a loose buffer tube, and then are or are not covered by a nonmetallic tape, wrap, or braid, (complete coverage is required) or by a jacket. Any covering applied shall be electrically nonconductive. A covering is not required over a loose buffer tube that is electrically nonconductive. Except that the tube or covering shall be electrically nonconductive, the materials, thickness, and other features of these elements are not specified.

14.2 No electrical element of the cable shall be located in an optical-fiber member or group of optical-fiber members. Strength members, moisture barriers, heat shields, and other nonelectrical parts of an optical-fiber member are not specified; however, where such part is of metal or other electrically conductive material, its presence shall be indicated by a marking as detailed in 43.1(e).

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14.3 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, 43.1 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 Two or more insulated conductors shall be assembled in a cable. Sizes may be mixed. A cable may contain precabled groups of conductors as described in 15.2.4.

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

15.2.4 The 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:

a) 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

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 15.1.

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.

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