UL 44

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Thermoset-Insulated Wires and Cables

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UL Standard for Safety for Thermoset-Insulated Wires and Cables, UL 44

Fifteenth Edition, Dated March 22, 1999

Revisions: This Standard contains revisions through and including May 13, 2002.

Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated August 25, 1997 and October 30, 1997. The announcement bulletin is located at the end of the Standard (after the adoption bulletin(s)).

Text that has been changed in any manner 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 UL's Bulletin(s) on this subject dated December 7, 2001. The bulletin(s) is now obsolete and may be discarded.

The revisions dated April 1, 2002 include a reprinted title page (page1) for this Standard.

Pages 70, 71, and 75 were revised on May 13, 2002 to indicate the revision dates of paragraphs 60.12, 60.16, 60.17, 60.34, 60.36, and 60.38.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-2	April 1, 2002
3	July 13, 2000
4	April 1, 2002
5	May 18, 2000
6	April 1, 2002
7	May 18, 2000
8	November 1, 2001
8A	April 1, 2002
8B-9	July 13, 2000
10	March 22, 1999
11	April 1, 2002
12-13	July 13, 2000
14	April 1, 2002
15	July 13, 2000
16-18	April 1, 2002
19	November 1, 2001
20-21	April 1, 2002
22-22B	July 13, 2000
23	March 22, 1999
24-27	April 1, 2002
28-31	March 22, 1999
32-34B	May 18, 2000
35	March 22, 1999
36-36B	April 1, 2002
37-38	March 22, 1999
39	April 1, 2002
40	July 13, 2000
41	March 22, 1999
42-43	April 1, 2002
44	March 22, 1999
45	April 1, 2002
46-47	July 13, 2000
48-50D	April 1, 2002
51	July 13, 2000
52	May 18, 2000
53-57	March 22, 1999
58-59	July 13, 2000
60	March 22, 1999
61	April 1, 2002
62-63	March 22, 1999
64-68	April 1, 2002
69	March 22, 1999
70-71	May 13, 2002
72-74	April 1, 2002
75	May 13, 2002
76-78	April 1, 2002

No Text on This Page

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UL 44

Standard for Thermoset-Insulated Wires and Cables

The First through Fifth editions were titled Rubber-Covered Wires and Cables. The Sixth through Thirteenth editions were titled Rubber-Insulated Wires and Cables.

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Fifteenth Edition

March 22, 1999

UL maintains this standard under the ANSI continuous maintenance procedure, resulting in each revision being designated as ANSI approved upon completion of the process. The Fifteenth Edition of UL 44, including revisions published through April 1, 2002, was designated as the American National Standard ANSI/UL 44 on March 1, 2002.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Approved as ANSI/UL 44 – 2002, March 1, 2002

The Department of Defense (DoD) has adopted UL 44 on April 5, 1985. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments on this standard should be made in writing to the UL-Melville Standards Department at 1285 Walt Whitman Road, Melville, New York 11747–3081.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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CONTENTS

METAL COVERINGS

LAY OF CABLED CONDUCTORS

ASSEMBLIES THAT INCLUDE SINGLE-CONDUCTOR THERMOSET-INSULATED WIRES

CABLE FOR DEEP-WELL SUBMERSIBLE WATER PUMPS

PERFORMANCE

DIELECTRIC VOLTAGE-WITHSTAND TEST IN WATER

TEST FOR INSULATION RESISTANCE AT 60.0°F (15.6°C)

TEST FOR INSULATION RESISTANCE IN WATER AT RATED TEMPERATURE

TEST FOR INSULATION RESISTANCE IN AIR AT 97.0°C (206.6°F)

ALTERNATIVE SPARK TESTING

CAPACITANCE AND RELATIVE-PERMITTIVITY TESTS

No Text on This Page

FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover 14 – 4/0 AWG and 213 – 2000 kcmil sizes of Type XHHW-2, XHHW, XHH, RHW-2, RHH, RHW, SIS, and SA wires and cables for use in accordance with Article 310 and other applicable parts of National Electrical Code. Deep-well pump cables and other multiple-conductor assemblies to which a type-letter designation is not assigned are included in these requirements.

1.1 revised April 1, 2002

1.2 These requirements do not cover wires or cables for use at potentials higher than 2000 V.

1.3 Although these requirements cover parallel and cabled assemblies of two or more insulated conductors, they do not cover complete armored (AC series), metal-clad (Type MC), medium-voltage (Type MV), or service-entrance (Types SE and USE) cables. These cables are covered in separate requirements.

1.4 Deleted November 1, 2001

2 Units of Measurement

2.1 In addition to being stated in the inch/pound units that are customary in the USA, each numerical requirement 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 exactly identical – results are to be expected from applying a requirement in USA or metric terms. Equipment calibrated in metric units is to be used when a requirement is applied in metric terms.

2.1 revised April 1, 2002

3 References

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

4 Materials

4.1 Each material used in a thermoset-insulated wire or cable shall be compatible with all of the other materials in the wire or cable.

5 Index Table

5.1 A thermoset-insulated wire or cable shall be as specified in Table 5.1 or 5.2 and shall comply in all respects with the requirements for the construction details and test performance that are applicable to that construction.

No Text on This Page

5.2 The table serves as an index to the requirements for construction details and test performance. Each vertical column serves as an index to the requirements that apply to the particular wire or cable whose type letters appear at the top of the column. The figures in parentheses are the numbers of the paragraphs in the text of this Standard, to which reference is to be made. References in square brackets are to UL 1581.

Table 5.1
Index to requirements[a] for XHHW-2, XHHW, XHH, RHH, RHW-2, and RHW

Table 5.1 revised April 1, 2002

Type-letter designation	XHHW-2	XHHW	XHH	RHH	RHW-2	RHW
Maximum Temperature	90°C (194°F) wet or dry	75°C (167°F) wet 90°C (194°F) dry	90°C (194°F) dry	90°C (194°F) dry	90°C (194°F) wet or dry	75°C (167°F) wet or dry
Maximum Voltage	600			600 or 2000		
Conductor Size	14 AWG – 2000 kcmil (Table 7.1)					
Number of Conductors	One, 2 parallel, 2 or more cabled					
Conductor Metal	14 and 13 AWG – soft-annealed copper, 12 AWG – 2000 kcmil – aluminum, copper-clad aluminum, or soft-annealed copper (6.1)					
Conductor Dimensions	See 8.1 – 8.3 for diameter and cross-sectional area					
Conductor – General	Metal coating (9.1 and 9.2) Splices (10.1 and 10.2) Separator (13.1 and 13.2)					
Conductor Resistance	(11.1)					
Conductor Stranding	(12.1 – 12.7)					
Insulation Material(s)[b]	XL EPCV			SBR/IIR/NR CP CPE EPCV EP XL Silicone rubber (RHH only)		
Insulation – General	Application (14.1), Joints (14.2), Other materials (14.3), Centering (16.1)					
Thickness of Insulation – Average	(15.1)					
Thickness of Insulation – Minimum at Any Point	(15.1)					

Table 5.1 Continued on Next Page

Table 5.1 Continued

Type-letter designation			XHHW-2	XHHW	XHH	RHH	RHW-2	RHW
Nonmetallic Coverings and Fillers			(17.1 and 17.2)			General (17.1 and 17.2) Number of Coverings (18.1 – 18.4) Fillers (19.1) Tapes (20.1 – 20.4) Cotton Braids (21.1 – 21.2.7) All-Glass and Glass/Cotton Braids (22.1 – 22.4) Aramid Braid (22.5) Cotton Wraps and Servings (23.1.1 – 23.2.4) Glass Wraps (24.1 and 24.2) Spun-Rayon Braids and Wraps (25.1) Saturation of Fibrous Coverings (26.1– 26.4) Finish (27.1) CP CPE Neoprene (RHW, RHH, RHW-2) NBR/PVC (RH, RHW) Thickness of Jacket (28.1) Lubrication (29.1)		
Lay of Cabled Conductors			(33.1)					
Assemblies That Include Single- Conductor Thermoset-Insulated Wires			(34.1)					
Pump Cable	General		(1.1, 19.1, 29.1, 33.1, 35.1, 60.6, 60.7, and 60.32)		none		(1.1, 19.1, 29.1, 33.1, 35.1, 60.6, 60.7, and 60.32)	
	Thickness of Jacket		(35.1)		none		(35.1)	
	Physical Properties of Jacket		(35.1)		none		(35.1)	
Physical Properties of Insulation[b]		Unaged	XL EPCV			SBR/IIR/NR CP CPE EPCV EP XL Silicone rubber (RHH only)		
		After Aging						
Physical Properties of Jacket[b]		Unaged	none			CP CPE Neoprene NBR/PVC		
		After Aging						
Dielectric Voltage-Withstand			(36.1 – 36.3)					
Insulation Resistance at 60.0°F (15.6°C)			(37.1 and 38.1)					
Insulation Resistance in Water at Rated Temperature			(39.1.1 – 39.3.1)		none		(39.1.1– 39.3.1)	
Insulation Resistance in Air at 97.0°C (206.6°F)			none	(40.1.1 – 40.3.2)			none	
Alternative Spark Testing			(41.1)					
Continuity			[pars. 900.13 – 900.17 of UL 1581]					

Table 5.1 Continued on Next Page

Table 5.1 Continued

Type-letter designation	XHHW-2	XHHW	XHH	RHH	RHW-2	RHW
Capacitance and Relative Permittivity	(42.1)		none		(42.1)	
Stability Factor	(43.1)		none		(43.1)	
Glass Content	none			(22.1)		
Falling Particles and Dripping from Fibrous Coverings	none			(45.1)		
Moisture Absorption by Fibrous Coverings Other Than Tape	none			(46.1)		
Cold Bend	(47.1)					
Cold Impact	(48.1)					
Deformation	(49.1)					
Crushing	(50.1 and 50.2)			none		
Glancing Impact	(51.1)			none		
Scoring	(52.1)			none		
Horizontal Flame	(53.1)					
VW-1 Flame	(54.1)					
Vertical-Tray Flame	Single- and multiple-conductor (55.1 – 55.4)					
Tray Cables Sunlight Resistance	Single- and jacketed multiple-conductor (56.1 – 56.4)					
Sunlight Resistance for Messenger Use	Single- and jacketed multiple-conductor (56.1– 56.4)	Messenger use not applicable	Single- and jacketed multiple-conductor (56.1 – 56.4)	Messenger use not applicable	Single- and jacketed multiple-conductor (56.1 – 56.4)	Messenger use not applicable
Oil Resistance	(57.1 and 57.2)					
Gasoline- and Oil-Resistance	(58.1)					
Markings	(60.1– 60.44)					

[a] See 5.2.

[b] The physical properties requirements for individual material are in UL 1581. See 47.1 in UL 1581. See also 40.2 in UL 1581.

Table 5.2
Index to requirements[a] for Types SA and SIS

Table 5.2 revised April 1, 2002

Type-letter designation		SA	SIS
Maximum Temperature		90°C (194°F) dry 200°C (392°F) special dry	90°C (194°F) dry
Maximum Voltage		600	
Conductor Size		14 AWG – 2000 kcmil (6.1, 8.1)	14 – 4/0 AWG (6.1, 8.1)
Number of Conductors		One, 2 parallel, 2 or more cabled	
Conductor Metal		Soft-annealed copper	14, 13 AWG soft-annealed copper, 12 – 4/0 AWG – aluminum, copper-clad aluminum, or soft-annealed copper (6.1)
Conductor Dimensions		See 8.1– 8.3 for diameter and cross-sectional area	
Conductor – General		Metal coating (9.1 and 9.2) Splices (10.1 and 10.2) Separator (13.1 and 13.2)	
Conductor Resistance		(11.1)	
Conductor Stranding		(12.1 – 12.7)	
Insulation Material(s)[b]		200°C silicone	CP CPE EPCV XL
Insulation – General		Application (14.1) Joints (14.2) Other material (14.3) Centering (16.1)	
Thickness of Insulation– Average		(15.1)	
Thickness of Insulation – Minimum at Any Point		(15.1)	
Nonmetallic Coverings and Fillers		General (17.1 and 17.2) Number of Coverings (18.1– 18.4) Fillers (19.1) Tapes (20.1 – 20.4) Glass Braids (22.1 – 22.4) Aramid Braids (22.5) Saturation of Fibrous Coverings (26.1– 26.4) Finish (27.1) Lubrication (29.1)	none
Lay of Cabled Conductors		(33.1)	
Assemblies That Include Single- Conductor Rubber-Insulated Wires		(34.1)	
Physical Properties of Insulation[b]	Unaged	200°C silicone	EPCV, XL CP, CPE
	After Aging		

Table 5.2 Continued on Next Page

Table 5.2 Continued

Type-letter designation	SA	SIS
Dielectric Voltage-Withstand	(36.1 – 36.3)	
Insulation Resistance at 60.0°F (15.6°C)	(37.1 and 38.1)	
Alternative Spark Testing	(41.1)	
Continuity	[pars. 900.13 – 900.17 of UL 1581]	
Glass Content	(44.1)	none
Cold Bend	(47.1)	
Cold Impact	(48.1)	
Deformation	none	(49.1)
Horizontal Flame Test	(53.1)	
VW-1 Flame Test	(54.1)	
Vertical-Tray Flame Test	(55.1 – 55.4)	
Markings	(60.1 – 60.41)	

[a]See 5.2.

[b]The physical properties requirements for individual material are in UL 1581. See 47.1 of UL 1581. See also 40.2 of UL 1581.

CONDUCTOR(S)

6 Metal

6.1 Only soft-annealed copper, copper-clad aluminum, or an aluminum alloy shall be used for the conductor or conductors in a wire or cable. Soft-annealed copper shall comply with ASTM B 3-01. Each 27 – 36 AWG (14.2 – 5.0 mils or 0.361 – 0.127 mm) strand in wire rated for 200°C (392°F) shall be protected against oxidation by a coating of nickel complying with ASTM B 355-95, a coating of silver complying with ASTM B 298-99, or a coating of another metal or alloy (evaluation required – lead, tin/lead, and tin coatings are not acceptable). Uncoated or tin/lead-coated or tin-coated solid conductors and uncoated or tin/lead-coated or tin-coated strands whose diameter is at least 0.015 inch or 0.38 mm are acceptable in wire rated for 200°C (392°F). Solid aluminum conductors in size 12 – 8 AWG shall comply with the requirements for aluminum-wire stock (aluminum-alloy conductor material). All other aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in Requirements for Aluminum Conductors of an 8000 Series Alloy, Section 10 of UL 1581. Copper-clad aluminum conductors shall comply with the requirements in Requirements for Copper-Clad Aluminum Conductors, Section 11 of UL 1581.

6.1 revised April 1, 2002

7 Size, Temper, and Assembly

7.1 Conductors shall be of the size, temper, and assembly indicated for the finished wire type in Table 7.1.

Table 7.1
Conductors

Table 7.1 revised April 1, 2002

Types of wire	Sizes and metal (See Tables 5.1 and 5.2)	Temper	Assembly
XHHW-2, XHHW, XHH, RHH, RHW, RHW-2, SIS[a], SA	14 – 4/0 AWG copper	Soft-annealed	Solid
	2 – 4/0 AWG copper	Soft-annealed	Compact stranding [b,f]
	14 AWG – 2000 kcmil copper	Soft-annealed	Compressed stranding and every other type of stranding[b] covered in Table 210.1 of UL 1581 other than compact stranding
XHHW-2, XHHW, XHH, RHW-2, RHH, RHW, SIS[a]	12 – 8 AWG aluminum	[c]	Solid
	6 – 4/0 AWG aluminum	Semi-annealed[d]	Solid
	12 AWG – 2000 kcmil aluminum	Semi-annealed[d]	Compressed stranding and every other type of stranding[b] covered in Table 210.2 of UL 1581 other than compact stranding
	12 AWG – 1000 kcmil aluminum	Semi-annealed[d]	Compact stranding[b]
	12 – 4/0 AWG copper-clad aluminum	[d]	Solid
	12 AWG – 2000 kcmil copper-clad aluminum	[d]	Any type of stranding[b] covered in Table 210.2 of UL 1581 other than compact and compressed stranding

[a] Type SIS is limited to 14 – 4/0 AWG copper and 12 – 4/0 AWG aluminum and copper-clad aluminum.

[b] See 12.1 – 12.7.

[c] Aluminum-wire stock (aluminum-alloy conductor material).

[d] See 6.1.

[e] *Deleted.*

[f] See 60.39.

8 Conductor Diameter and Cross-Sectional Area

8.1 The nominal, maximum (1.01 x nominal), and minimum (0.98 x nominal) diameters of solid and stranded conductors are shown in Tables 20.1, 20.2, 20.3, 20.3.1, 20.4, 20.5, and 20.6 of UL 1581. Conductor diameter is to be measured using the method shown in Conductor Diameter, Section 200 of UL 1581.

8.1 revised March 22, 1999

8.2 Compressed unilay copper conductors that are smaller in diameter than the requirement (0.98 x nominal as indicated in Table 20.3 of UL 1581) for compressed concentric-lay conductors shall be marked the same as compact conductors in accordance with 60.39.

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

9 Metal Coating

9.1 Where the insulation adjacent to a copper or copper-clad aluminum conductor is of a material that corrodes unprotected copper in the test in Conductor Corrosion, Section 500 of UL 1581, and where 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 coating of tin complying with ASTM B 33-00, of a tin/lead alloy complying with ASTM B 189-95, of nickel complying with ASTM B 355-95, of silver complying with ASTM B 298-99, or of another metal or alloy (evaluation required).

9.1 revised April 1, 2002

9.2 The use of a metal coating, when not required for corrosion protection, is still appropriate for use on solid or individual wires (strands) or selected wires, such as the outer layer of wires of a stranded conductor. The metal coating when used shall comply with 9.1

9.2 revised March 22, 1999

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 and shall not change the diameter of the solid conductor, the individual wire strand, or the overall stranded conductor. A joint shall not be made in a stranded conductor as a whole. A joint in a stranded conductor shall be made by separately joining each individual wire. A joint shall be made only before any coverings are applied to an insulated conductor and before a conductor is assembled into a cable. The insulation applied to such joints shall be equivalent to that removed and shall comply with the requirements in this Standard. A joint in a compact- or compressed-stranded conductor shall be made before compacting or compressing.

10.1 revised March 22, 1999

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), splices of the members as individual units shall not be closer together than two lay lengths.

10.2 revised March 22, 1999

11 Resistance

11.1 The direct-current resistance of any length of conductor in ohms per thousand conductor feet or in ohms per conductor kilometer shall not be higher than the maximum (nominal x 1.02) resistance indicated in the applicable table in D-C Conductor Resistance, Section 30 of UL 1581 at 20°C (68°F) or at 25°C (77°F) when measured as described in D-C Conductor Resistance, Section 220 of UL 1581. The d-c resistance of each conductor in a finished Type XHHW-2M, XHHWM, XHHM, RHW-2M, RHHM, RHWM, RHM, SISM, or SAM cable shall not exceed the value tabulated in the applicable one of the tables in Section 30 of UL 1581 for a single conductor multiplied by whichever of the following factors is applicable:

Construction	Multiplier
Cabled in one layer	1.02
Cabled in more than one layer	1.03
Cabled as one pair	1.04
Cabled as an assembly of pairs or other precabled units.	1.04

11.1 revised March 22, 1999

12 Stranding

12.1 A stranded conductor shall have the number of strands indicated in Table 12.1.

Table 12.1
Conductor stranding

Table 12.1 revised November 1, 2001

Size of wire	Number of strands in combination unilay	Minimum number of strands[b]	
		Compact stranded	All others
AWG			
14, 13	19[a]	–	7
12 – 9	19[a]	7	7
8	19[a]	7	7
7 – 2	19	7	7
1 – 4/0	19	18	19
kcmil			
213 – 500	–	35	37
501 – 1000	–	58	61
1001 – 1500	–	–	91
1501 – 2000	–	–	127

[a] Copper only.

[b] Conductors with a lesser number of strands shall be permitted based on the results of an investigation which shall include testing for connectability and bending.

12.2 The individual wires used in making up a stranded conductor are usually drawn to the same diameter which is not required to be the diameter of any AWG or other standard gauge number.

12.2 revised March 22, 1999

12.3 Copper strands smaller than 36 AWG and aluminum and copper-clad aluminum strands smaller than 22 AWG shall not be used.

12.3 revised April 1, 2002

12.4 A 19-wire combination round-wire unilay-stranded conductor of soft-annealed copper, or an aluminum alloy as indicated in 6.1, 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. However, 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 bunch-stranding shall comply with 12.6 or 12.7 as applicable. 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]

Table 12.2 revised May 14, 2001

AWG size of conductor	Maximum length of lay	
	inches	mm
14 AWG	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
5 AWG – 2000 kcmil	16 times the diameter of the conductor	

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

12.5 A compact-stranded conductor shall be a round conductor consisting of a central core (one or more strands) surrounded by one or more layers of helically laid strands. A compact-stranded copper conductor shall consist of uncoated strands. A compact-stranded aluminum conductor shall have all layers with the same direction of lay (left-hand unidirectional). A compact-stranded copper conductor is to be left- hand unidirectional or have the direction of lay reversed in adjacent layers (concentric-lay-stranded with the outer layer left-handed) and with each layer rolled, drawn, or otherwise compressively formed to change 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 a smooth, round outer surface. The length of lay of the strands in the outer layer of a 1 AWG – 1000 kcmil 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 12 – 2 AWG conductor shall be 8.0 – 17.5 times the overall diameter of that layer. A compact-stranded conductor shall not be segmented.

12.5 revised November 1, 2001

12.6 A compressed-stranded conductor shall be a round conductor consisting of a central core (one or more strands) surrounded by one or more layers of helically laid strands with either the direction of lay reversed in successive layers, or of unilay or unidirectional lay. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers may be 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.

12.6 revised November 1, 2001

12.7 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 6 AWG – 2000 kcmil conductor other than a combination unilay or compressed unilay or compressed unidirectional lay conductor shall be reversed in successive layers. Rope-bunched lay and rope-concentric lay conductors 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 the member. 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 copper or aluminum 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 the conductor.

e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded or compressed 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.

12.7 revised April 1, 2002

13 Separator

13.1 The insulation shall be kept by the manufacturing process or a separator from penetrating between the strands of a conductor (see Insulation Fall-In Test, Section 520 of UL 1581). A separator is not required between the conductor and the insulation of a solid or stranded wire or cable. When used a separator shall be electrically nonconductive (an insulation grade is not required) and shall not be counted as part of the required insulation.

13.1 revised March 22, 1999

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

13.2 revised March 22, 1999

INSULATION

14 Material and Application

14.1 A single-conductor wire or cable and each conductor of a multiple-conductor cable shall be insulated for its entire length with one of the insulations specified for the construction in Table 5.1 or 5.2. The insulation shall be applied directly to the surface of the conductor or to any separator and shall cover the conductor or any separator completely. The insulation shall fit tightly to the conductor and shall not adhere. For the case of an insulated conductor for use in a pump cable, see tag marking required in 60.34(g). The insulation shall not have any defects visible with normal or corrected vision without magnification.

14.1 revised March 22, 1999

14.2 Any repair or joint in the insulation shall be made in a workmanlike manner resulting in all parts affected in the process complying with the same electrical tests as the remainder of the insulation. The thickness of insulation at the repaired part or joint shall comply with the requirements in 15.1.1.

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

a) Material generically different from any insulation or jacket material that is named in Table 5.1 or 5.2 for the construction (new material).

b) Material that is named in Table 5.1 or 5.2 yet does not comply with the short-term tests specified for the material in Specific Materials, Section 50 of UL 1581.

The temperature rating of materials (a) and (b) shall be as required for the specific thermoset-insulated wire or cable type. The thickness of insulation and/or jacket using materials (a) and/or (b) shall be as required for the specific type. Investigation of the electrical, mechanical, and physical characteristics of the wire or 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 5.1 or 5.2 for the required temperature rating. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock, insulation resistance, and dielectric voltage-withstand, or other tests as appropriate.

14.3 revised July 13, 2000

15 Thicknesses of Insulation

15.1 General

15.1.1 The average thickness of the insulation and the minimum thickness at any point of the insulation on an individual conductor shall not be less than indicated in Table 15.1, 15.2, 15.3, 15.4, 15.5, or 15.6 as applicable to the particular type, size, and voltage rating of the wire when determined as described in Thickness of Insulation and Jacket, Section 240 of UL 1581. In addition, when two layers of XL and/or EPCV insulation are used, the insulation compounds shall be those that individually comply with the requirements for Type RHW or RHH when applied in a single layer of the thicknesses indicated in Table 15.4 (600-volt rating) or 15.5 (2000-volt rating). The total thicknesses shall not be less than indicated in Table 15.4 or 15.5 for a single layer and neither layer shall be less than 10 mils or 0.25 mm thick.

15.1.1 revised March 22, 1999

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Table 15.1
Thicknesses of insulation on Type SA wire
(silicone under a glass or aramid braid)

Table 15.1 revised March 22, 1999

	mils		mm	
Size of conductor	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
AWG				
14 – 10	45	40	1.14	1.02
9 – 2	60	54	1.52	1.37
1 – 4/0	80	72	2.03	1.83
kcmil				
213 – 500	95	86	2.41	2.18
501 – 1000	110	99	2.79	2.51
1001 – 2000	125	112	3.18	2.84

Table 15.2
Thicknesses of insulation on Type SIS wire
(EPCV or CP or CPE or XL under no covering)

Table 15.2 revised March 22, 1999

	mils		mm	
Size of conductor	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
AWG				
14 – 10	30	27	0.76	0.69
9 – 2	45	40	1.14	1.02
1 – 4/0	55	50	1.40	1.27

Table 15.3
Thicknesses of insulation on Type XHHW-2, XHHW, and XHH wires
(Class XL or EPCV under no covering)

Table 15.3 revised March 22, 1999

	mils		mm	
Size of conductor	Minimum average thickness	Minimum thickness at any point	Minimum average thickness	Minimum thickness at any point
AWG				
14 – 10	30	27	0.76	0.69
9 – 2	45	40	1.14	1.02
1 – 4/0	55	50	1.40	1.27
kcmil				
213 – 500	65	58	1.65	1.47
501 – 1000	80	72	2.03	1.83
1001 – 2000	95	86	2.41	2.18

Table 15.4
Thicknesses of insulation on 600-V Type RHW-2, RHH, and RHW wires

Table 15.4 revised April 1, 2002

Size of conductor	Wire with insulation consisting of Class SBR/IIR/NR under a neoprene, NBR/PVC, CPE or CP jacket or a fibrous covering and wire with insulation consisting of silicone rubber (RHH only) or EP under a neoprene, NBR/PVC, CPE, or CP jacket or a fibrous covering and wire with insulation consisting of Class CP, CPE, or XL or EPCV under no covering				Wire with composite insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP without any outer covering											
					Inner Layer – EP						Outer Layer – CP, CPE, EPCV, or XL					
	Minimum thickness				Minimum thickness						Minimum thickness					
	mils		mm		mils			mm			mils			mm		
	Average	At any point	Average	At any point	Average	At any point[a]		Average	At any point[a]		Average	At any point[a]		Average	At any point[a]	
						A	B		A	B		A	B		A	B
AWG																
14 – 10	45	40	1.14	1.02	30	27	28	0.76	0.69	0.71	15	14	12	0.38	0.36	0.30
9, 8, 7	60	54	1.52	1.37	45	40	42	1.14	1.02	1.07	15	14	12	0.38	0.36	0.30
6 – 2	60	54	1.52	1.37	45	40	44	1.14	1.02	1.12	30	27	24	0.76	0.69	0.61
1 – 4/0	80	72	2.03	1.83	55	50	54	1.40	1.27	1.37	45	40	36	1.14	1.02	0.91
kcmil																
213 – 500	95	86	2.41	2.18	65	58	65	1.65	1.47	1.65	65	58	52	1.65	1.47	1.32
501 – 1000	110	99	2.79	2.51	80	72	78	2.03	1.83	1.98	65	58	52	1.65	1.47	1.32
1001 – 2000	125	112	3.18	2.84	–	–	–	–	–	–	–	–	–	–	–	–

[a] The minimum thickness at any point shall not be less than indicated in column A or B under Inner Layer with the minimum thickness at any point not less than indicated in the corresponding column A or B under Outler Layer. The thickness in column B under Inner Layer plus the thickness in Column B under Outler Layer equals 90 percent of the sum of the average thicknesses indicated under Inner Layer and Outler Layer.

Table 15.5
Thicknesses of insulation on 2000-V Type RHW-2, RHH, and RHW wires

Table 15.5 revised April 1, 2002

Size of conductor	Wire with insulation consisting of silicone rubber (RHH only) or EP under a neoprene, NBR/PVC, CPE, or CP jacket or a fibrous covering and wire with insulation consisting of Class XL or EPCV under no covering				Wire with insulation consisting of CP or CPE under no covering and wire with insulation consisting of Class SBR/IIR/NR under a neoprene, NBR/PVC, CPE, or CP jacket or a fibrous covering				Wire with composite insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP without any outer covering									
									Inner Layer – EP						Outer Layer – CP, CPE, EPCV, or XL					
	Minimum thickness								Minimum thickness						Minimum thickness					
	mils		mm		mils		mm		mils			mm			mils			mm		
	Avg.	At any point	Avg.	At any point	Avg.	At any point	Avg.	At any point	Avg.	At any point[a]		Avg.	At any point[a]		Avg.	At any point[a]		Avg.	At any point[a]	
										A	B		A	B		A	B		A	B
AWG																				
14 – 10	60	54	1.52	1.37	80	72	2.03	1.83	45	40	42	1.14	1.02	1.07	15	14	12	0.38	0.36	0.30
9	70	63	1.78	1.60	80	72	2.03	1.83	55	50	51	1.40	1.27	1.30	15	14	12	0.38	0.36	0.30
8, 7	70	63	1.78	1.60	80	72	2.03	1.83	55	50	52	1.40	1.27	1.32	30	27	24	0.76	0.69	0.61
6 – 2	70	63	1.78	1.60	95	86	2.41	2.18	55	50	52	1.40	1.27	1.32	30	27	24	0.76	0.69	0.61
1 – 4/0	90	81	2.29	2.06	110	99	2.79	2.51	65	58	63	1.65	1.47	1.60	45	40	36	1.14	1.02	0.91
kcmil																				
213 – 500	105	94	2.67	2.39	125	112	3.18	2.84	75	68	74	1.90	1.73	1.88	65	58	52	1.65	1.47	1.32
501 – 1000	120	108	3.05	2.74	140	126	3.56	3.20	90	81	88	2.29	2.06	2.24	65	58	52	1.65	1.47	1.32
1001 – 2000	140	126	3.56	3.20	140	126	3.56	3.20	115	104	113	2.92	2.64	2.87	95	85	76	2.41	2.16	1.93

[a] The minimum thickness at any point shall not be less than indicated in Column A or B under Inner Layer with the minimum thickness at any point not less than indicated in the corresponding Column A or B under Outer Layer. The thickness in Column B under EP plus the thickness in Column B under Outer Layer equals 90 percent of the sum of the average thicknesses indicated under Inner Layer and Outer Layer.

Table 15.6
Thicknesses of insulation on Type RH wire

Table 15.6 deleted July 13, 2000

16 Centering

16.1 The insulation shall have a circular cross section, shall be applied concentrically about the conductor or any separator (making the conductor plus any separator well centered in the insulation), and shall fit tightly on the conductor or any separator. When the insulation is applied in more than one layer, adjacent layers shall be vulcanized, cured, or cross-linked into an integral mass and this mass shall be taken as a whole for all measurements and tests with the exception that the thicknesses of the layers of composite insulation shall be measured separately.

NONMETALLIC COVERINGS AND FILLERS

17 General

17.1 A single-conductor wire or cable, and each conductor of any 2-conductor flat parallel wire or cable and of any cabled multiple-conductor cable, shall have a covering of fibrous material or a jacket applied over the outer surface of the insulation unless it is indicated in note [a] to the physical-properties table in UL 1581 (see Table 50.1, 50.62, and 50.231 of UL 1581) that a covering is not required over the insulation. A covering other than the tape, braid, wrap, neoprene jacket, NBR/PVC jacket, CPE jacket, or CP jacket described in this Standard is to be evaluated. See 14.3 for the long-term evaluation of a jacket material not named in Table 5.1 or 5.2 or not complying with the short-term tests specified for the material in Specific Materials, Section 50 of UL 1581.

17.1 revised March 22, 1999

17.2 A fibrous covering when used, shall be applied to the insulated conductor either before or after the process of vulcanizing, curing, or cross-linking the insulating compound. A separator, when used, shall be between the insulation and the fibrous covering.

18 Number of Coverings

18.1 A single-conductor 600-V 14 – 7 AWG wire or cable that is insulated with a material over which a covering is required shall have one or more fibrous coverings or a jacket. A single-conductor 600-V 6 AWG – 2000 kcmil wire or cable and a single conductor 2000-V 14 AWG – 2000 kcmil wire or cable that is insulated with a material over which a covering is required shall have two or more fibrous coverings or a jacket. However, when the wire or cable is for use in armored cable the wire or cable shall have one or more fibrous coverings or a jacket..

18.1 revised April 1, 2002

18.2 A multiple-conductor cable shall have, in addition to the individual-conductor covering required in 17.1, a fibrous covering or jacket enclosing the parallel or cabled conductors.

18.2 revised March 22, 1999

18.3 Deleted March 22, 1999

18.4 When a wire or conductor assembly is intended and tagged or otherwise marked for further processing (such as for use in armored cable), the second fibrous covering required in 18.1 for a single-conductor wire and the overall fibrous covering required in 18.2 for a multiple-conductor assembly are not required. When a second fibrous covering is provided it is not required to comply with the requirements for braids or wraps in 21.1.1 – 25.1.

18.4 revised March 22, 1999

19 Fillers

19.1 Fillers are not required in a pump cable or other multiple-conductor cable or assembly. Fibrous fillers used elsewhere than in a jacketed cable shall be of polypropylene, glass, or other moisture-resistant material or shall be made moisture-resistant by means of a saturant.

19.1 revised March 22, 1999

20 Tapes

20.1 Tape shall not be the final outer covering of a single- or multiple-conductor wire or cable. Tape is otherwise appropriate as a fibrous covering.

20.2 When more than one layer of cloth or nylon tape is applied, the thickness of each tape layer shall be added together to meet the required minimum thickness. Except as noted in 20.3, any tape used shall consist of any convenient width elastomer filled woven cloth or nylon tape that is treated on one or both sides and is not less than 8.0 mils or 0.2 mm thick for cloth or 6.0 mils or 0.15 mm for nylon. A tape shall be applied helically without any creases or folds and with an overlap of at least 1/8 inch or 3 mm on 8 AWG and smaller conductors and at least 1/4 inch or 6 mm on larger conductors.

20.2 revised April 1, 2002

20.3 A covering consisting of a tape other than the elastomer-filled tape described in 20.2 is to be at least equivalent to the covering described in 20.2. A tape of polypropylene or oriented polyethylene terephthalate not less than 1.0 mil or 0.03 mm thick shall be applied either helically or longitudinally, with the specified overlap, only under a braid or wrap covering on an individual wire (such tape is required under the braid on a 6 AWG – 2000 kcmil Type SA cable).

20.3 revised April 1, 2002

20.4 The thickness of a tape is to be determined by removing the tape from the insulation and measuring its thickness by means of a dead-weight dial micrometer having a presser foot 0.250 ±0.010 inch or 6.4 ±0.1 mm in diameter and exerting 3.0 ±0.1 ozf or 85 ±3 gf or 0.83 ±0.02 N on the tape, the load being applied by means of a weight.

21 Cotton Braids

21.1 General

21.1.1 A cotton braid employed as a covering on an individual conductor or as an outer covering over two or more individual conductors shall be of a close weave, shall cover the insulated conductor or conductors over which it is applied, and shall be fabricated on a machine having the same number of ends per carrier throughout. Each end shall consist of the same kind (soft or glazed), size, and ply of yarn. The braid shall be applied to make the tangent of the lay angle (the angle of weave with reference to the axis of the wire or cable) not less than indicated in Table 21.1.

Table 21.1
Cotton-braid angles

Calculated diameter under braid		Value of tangent	Corresponding braid angle in degrees
inches	mm		
0 – 1.000	0 – 25.4	0.700	35
1.001 – 1.500	25.5 – 38.1	0.839	40
over 1.500	over 38.1	1.000	45

21.1.2 A cotton braid shall employ yarn in accordance with Table 21.2.

Table 21.2
Cotton yarn sizes

Calculated diameter under braid		Minimum size and ply of yarn
inches	mm	
0.200 or less	5.08 or less	14/1 or 30/2
0.201 – 0.350	5.11 – 8.89	12/1 or 26/2
0.351 – 0.800	8.92 – 20.32	10/1 or 20/2
0.801 – 1.500	20.35 – 38.10	12/2
1.501 – 3.000	38.13 – 76.20	8/2

21.1.3 Single-ply yarn shall be used only when the diameter under the braid is not larger than 0.800 inch or 20.32 mm. Otherwise, at least 2-ply yarn shall be employed.

21.1.4 In determining the lay angle and yarn size for the overall braid of a twin wire (parallel conductors), a value equal to 1.64 times the diameter of the individual insulated conductor is to be taken as the diameter under the braid.

21.2 Coverage

21.2.1 The size, ply, and number of ends of yarn and the length of lay shall make the percent coverage Q of a cotton braid in each direction at least 40 percent when the diameter under the braid is not larger than 0.500 inch or 12.7 mm, and at least 50 percent when the diameter under the braid is larger than 0.500 inch or 12.7 mm. Coverage is to be computed by means of whichever of the following formulas is applicable.

$$Q = \frac{100\ NET_{in}}{\sin A}$$

in which:

N is the number of picks per inch,

E is the number of ends per pick,

T is the diameter of one end of yarn in inches, and

A is the lay angle; or

$$Q = \frac{NET_{mm}}{25.4 \sin A}$$

in which:

N is the number of picks per centimeter,

E is the number of ends per pick,

T is the diameter of one end of yarn in millimeters, and

A is the lay angle.

21.2.2 The number N of picks per inch or per centimeter is to be measured by means of a standard braid counter at three places that are at least 2 inches or 50 mm apart in any 12-inch or 300-mm section in the center 3 ft or 1 m of a 5-ft or 1500-mm specimen of the braid-covered wire or cable. The outer surface of the specimen is to be wiped with a cloth wet with an organic solvent. The average of the three determinations is to be taken as the number of picks per inch or the number of picks per centimeter for that specimen.

21.2.3 Values of yarn diameter used in determining picks per inch or picks per centimeter by the applicable formula in 21.2.5 were computed by means of whichever of the following formulas applies

$$T_{in} = \frac{0.0279\,K}{(S)^{0.5}}$$

or

$$T_{mm} = \frac{0.7087\,K}{(S)^{0.5}}$$

in which:

T_{in} is the diameter of one end of yarn in inches,

T_{mm} is the diameter of one end of yarn in millimeters,

K is the cabling factor (1.00 for single-ply yarn and 1.60 for 2-ply yarn), and

S is the yarn size number.

21.2.4 The lay angle A is to be determined by means of the formula

$$\cos A = \frac{100\,CET}{pi\,Q\,(2\,T + D)}$$

in which:

C is the number of carriers in each direction,

E is the number of ends per pick,

T is the diameter of one end of yarn in inches (T_{in}) or in millimeters (T_{mm}),

Q is the minimum acceptable percent coverage in each direction, and

D is the diameter under the braid in inches or in millimeters.

21.2.5 By transposition, the formula in 21.2.1 becomes either

$$\text{Picks per inch} = N = \frac{Q \sin A}{100\, ET_{in}}$$

$$\text{Picks per centimeter} = N = \frac{25.4\, Q \sin A}{100\, ET_{mm}}$$

The transposed formula facilitates computation of the minimum number of picks per inch or the minimum number of picks per centimeter for any combination of factors when the lay angle, as determined by means of the formula in 21.2.4, is not less than indicated in Table 21.1.

21.2.6 Where two braids are used to achieve compliance with the requirement for two fibrous coverings in 18.1, the lay angle, yarn size, and coverage (including picks per inch or picks per centimeter) of each braid shall be determined on the basis of the diameter under that braid and the number of carriers on the machine applying that braid. For the outer braid, the diameter under that braid is to be taken as the diameter over the inner braid. It is appropriate for the number of carriers for the inner braid to be less than the number of carriers employed for the outer braid. However, the size and ply of the cotton yarn used shall comply with these requirements, and the number of ends per carrier in the inner braid shall not be less than the number of ends per carrier in the outer braid.

21.2.7 Tables 21.3 and 21.4 have been computed on the basis of 21.1.1 – 21.2.6 and give the minimum number of picks per inch (Table 21.3) and the minimum number of picks per centimeter (Table 21.4) for the braids most commonly used. The ranges of diameter given in the first column are for calculated diameters based on typical values of conductor diameter and insulation thickness. For a solid conductor, the nominal conductor diameter (mils are to be converted to inches by multiplying by 0.001) in Table 20.1 of UL 1581 is to be used. For a standard, round, concentric-lay-stranded conductor (ASTM Class B), the diameter in column A (inches) or B (millimeters) of Table 20.4 of UL 1581 is to be used. For a compressed-stranded conductor, the diameter in column P (inches) or Q (millimeters) of Table 20.3 of UL 1581 is to be used. For a compact-stranded conductor, the diameter in column A (inches) or B (millimeters) of Table 20.3 of UL 1581 is to be used. A braid complying with Table 21.3 or Table 21.4 has at least the minimum angle of lay and coverage. Braids are not limited to those covered in Tables 21.3 and 21.4 as long as they comply with the requirements in 21.1.1 – 21.2.6.

Table 21.3
Minimum number of picks per inch for some cotton braids

Calculated diameter under the braid in inches	Number of carriers	Size and ply of yarn, and number of ends per pick													
		14/1 or 30/2		12/1 or 26/2		10/1 or 20/2			12/2			10/2		8/2	
		2	3	2	3	2	3	4	2	3	4	3	4	3	4
0.100 – 0.125	12	22.1		20.0		17.6									
	16	17.8		15.1											
0.126 – 0.150	12	23.5	12.7	21.6	11.1	19.3	9.1								
	16	20.8		18.6		15.9									
	20	16.5		13.8											
0.151 – 0.175	12	24.4	14.2	22.4	12.8	20.3	11.0								
	16	22.5	10.6	20.4	8.6	18.0									
	20	19.8		17.4		14.6									
0.176 – 0.200	16	23.5	12.6	21.5	11.0	19.2	8.9								
	20	21.6		19.4		16.8									
	24	18.9		16.4		13.3									
0.201 – 0.225	16			22.0	12.3	20.0	10.5								
	20			20.5		18.2									
	24			18.4		15.7									
0.226 – 0.250	16			22.7	13.3	20.6	11.5								
	20			21.5	10.9	19.2	8.8								
	24			19.8		17.2									
0.251 – 0.300	16			23.2	14.1	21.2	12.5	7.4							
	20			22.3	12.5	20.1	10.7								
	24			21.1	10.2	18.8									
0.301 – 0.350	16			23.7	14.8	21.6	13.4	8.8							
	20			23.0	13.7	20.9	12.2	6.9							
	24			22.1	12.2	20.0	10.6								
0.351 – 0.400	16					21.9	13.8	9.4	14.2	8.2					
	20					21.4	12.9	8.1	13.4	6.7					
	24					20.7	11.9		12.4						
0.401 – 0.450	16					22.1	14.2	9.9	14.5	8.7					
	20					21.7	13.5	8.9	13.8	7.6					
	24					21.1	12.7	7.5	13.0						
0.451 – 0.500	16					22.2	14.4	10.2	14.6	9.0					
	20					21.9	13.8	9.3	14.1	8.2					
	24					21.4	13.1	8.1	13.5	7.0					
0.501 – 0.600	20					27.9	18.2	13.1	18.6	11.7	8.0				
	24					27.6	17.7	12.5	18.3	11.1	7.1				
0.601 – 0.800	20					28.1	18.3	13.5	18.8	12.2	8.7	11.0	7.7		
	24					27.9	18.2	13.2	18.7	11.8	8.2	10.6	7.1		

Table 21.3 Continued on Next Page

Table 21.3 Continued

Calculated diameter under the braid in inches	Number of carriers	Size and ply of yarn, and number of ends per pick													
		14/1 or 30/2		12/1 or 26/2		10/1 or 20/2			12/2			10/2		8/2	
		2	3	2	3	2	3	4	2	3	4	3	4	3	4
0.801 – 1.000	20								19.7	12.5	9.1	11.3	8.2	10.0	7.1
	24								19.5	12.3	8.8	11.1	7.8	9.7	6.7
1.001 – 1.200	24								19.7	12.5	9.1	11.3	8.3	10.0	7.1
	36								19.3	11.9	8.3	10.7	7.3	9.3	6.1
	48								18.7	11.0	7.0	9.7	5.7	8.1	
1.201 – 1.500	24								19.8	12.7	9.3	11.5	8.4	10.2	7.4
	36								19.5	12.3	8.8	11.1	7.7	9.7	6.7
	48								19.2	11.7	8.0	10.4	6.9	9.0	5.6
1.501 – 2.000	36													10.0	7.2
	48													9.8	6.6

Table 21.4
Minimum number of picks per centimeter for some cotton braids

Calculated diameter under the braid in millimeters	Number of carriers	Size and ply of yarn, and number of ends per picks													
		14/1 or 30/2		12/1 or 26/2		10/1 or 20/2			12/2			10/2		8/2	
		2	3	2	3	2	3	4	2	3	4	3	4	3	4
2.54 – 3.18	12	8.7		7.9		6.9									
	16	7.0		5.9											
3.20 – 3.81	12	9.3	5.0	8.5	4.4	7.6	3.6								
	16	8.2		7.3		6.3									
	20	6.5		5.4											
3.84 – 4.44	12	9.6	5.6	8.8	5.0	8.0	4.3								
	16	8.9	4.2	8.0	3.4	7.1									
	20	7.8		6.9		5.8									
4.47 – 5.08	16	9.3	5.0	8.5	4.3	7.6	3.5								
	20	8.5		7.6		6.6									
	24	7.4		6.5		5.2									
5.11 – 5.72	16			8.7	4.8	7.9	4.1								
	20			8.1		7.2									
	24			7.2		6.2									
5.74 – 6.35	16			8.9	5.2	8.1	4.5								
	20			8.5	4.3	7.6	3.5								
	24			7.8		6.8									
6.38 – 7.62	16			9.1	5.6	8.4	4.9	2.9							
	20			8.8	4.9	7.9	4.2								
	24			8.3	4.0	7.4									

Table 21.4 Continued on Next Page

Table 21.4 Continued

Calculated diameter under the braid in millimeters	Number of carriers	Size and ply of yarn, and number of ends per picks													
		14/1 or 30/2		12/1 or 26/2		10/1 or 20/2			12/2			10/2		8/2	
		2	3	2	3	2	3	4	2	3	4	3	4	3	4
7.65 – 8.89	16			9.4	5.8	8.5	5.3	3.5							
	20			9.1	5.4	8.2	4.8	2.7							
	24			8.7	4.8	7.9	4.2								
8.92 – 10.16	16					8.6	5.4	3.7	5.6	3.2					
	20					8.4	5.1	3.2	5.3	2.6					
	24					8.2	4.7		4.9						
10.19 – 11.43	16					8.7	5.6	3.9	5.7	3.4					
	20					8.5	5.3	3.5	5.4	3.0					
	24					8.3	5.0	3.0	5.1						
11.46 – 12.70	16					8.7	5.7	4.0	5.8	3.5					
	20					8.6	5.4	3.7	5.6	3.2					
	24					8.4	5.2	3.2	5.3	2.8					
12.73 – 15.24	20					11.0	7.2	5.2	7.3	4.6	3.2				
	24					10.9	7.0	4.9	7.2	4.4	2.8				
15.27 – 20.32	20					11.1	7.2	5.3	7.4	4.8	3.4	4.3	3.0		
	24					11.0	7.2	5.2	7.4	4.6	3.2	4.2	2.8		
20.35 – 25.40	20								7.8	4.9	3.6	4.5	3.2	3.9	2.8
	24								7.7	4.8	3.5	4.4	3.1	3.8	2.6
25.43 – 30.48	24								7.8	4.9	3.6	4.5	3.3	3.9	2.8
	36								7.6	4.7	3.3	4.2	2.9	3.7	2.4
	48								7.4	4.3	2.8	3.8	2.2	3.2	
30.51 – 38.10	24								7.8	5.0	3.7	4.5	3.3	4.0	2.9
	36								7.7	4.8	3.5	4.4	3.0	3.8	2.6
	48								7.6	4.6	3.2	4.1	2.7	3.5	2.2
38.13 – 50.80	36													3.9	2.8
	48													3.9	2.6

22 All-Glass and Glass/Cotton Braids

22.1 A glass braid and a combination glass-and-cotton braid on a Type SA or other wire shall comply with the requirements in 21.1.1 and 21.2.6, shall employ a glass yarn that is not smaller than 150-1/0, and shall provide a coverage in each direction of at least 40 percent when the diameter under the braid is not larger than 0.500 inch or 12.70 mm, and at least 50 percent when the diameter under the braid is larger than 0.500 inch or 12.70 mm. The glass content of an all-glass braid shall comply with the requirement in 44.1.

22.2 To determine whether or not a braid employing glass complies with the requirement in 22.1 with respect to lay angle and coverage, the table indicating the minimum number of picks per inch (Table 21.3) or the minimum number of picks per centimeter (Table 21.4) is to be used under the conditions indicated in Table 22.1.

22.3 Table 22.1 is based on the assumed use of 150-1/0 glass yarn. A smaller size yarn shall not be used. Any larger size of yarn shall have the required angle of lay and coverage.

22.3 revised March 22, 1999

No Text on This Page

22.4 In a combination braid, the ratio of glass to cotton is not specified. However, the usual construction is half cotton and half glass, with all-glass carriers in one direction and all-cotton carriers in the other direction.

22.5 An aramid braid used to replace glass shall have the same angle of lay and coverage as required for glass and a minimum yarn diameter of 0.0225 inch or 0.57 mm.

22.5 revised March 22, 1999

Table 22.1
Minimum picks per inch or picks per centimeter for all-glass and combination glass/cotton braids

<table>
<tr><th rowspan="2">Cotton size with which glass is used</th><th rowspan="2">Number of ends per carrier for glass</th><th colspan="2">Calculated diameter under braid</th><th colspan="2">Picks per inch (Table 21.3) or picks per centimeter (Table 21.4)</th></tr>
<tr><th>inches</th><th>mm</th><th>More than 50 percent glass</th><th>50 percent or less glass</th></tr>
<tr><td>14/1</td><td rowspan="3">Same as that specified for an all-cotton braid</td><td>0.200 or less</td><td>5.08 or less</td><td>As specified for 14/1 cotton</td><td rowspan="4">Same as that specified for an all-cotton braid employing yarn of the same size as that with which the glass is used</td></tr>
<tr><td>12/1</td><td>0.201 – 0.350</td><td>5.11 – 8.89</td><td>As specified for 12/1 cotton</td></tr>
<tr><td>10/1</td><td>0.351 – 0.800</td><td>8.92 – 20.32</td><td>As specified for 10/1 cotton</td></tr>
<tr><td>12/2</td><td>One more than that specified for an all-cotton braid</td><td>0.801 – 1.500</td><td>20.35 – 38.10</td><td>As specified for 12/2 cotton</td></tr>
<tr><td>8/2</td><td>Double the number specified for an all-cotton braid</td><td>1.501 – 2.00</td><td>38.13 – 50.80</td><td colspan="2">As specified for 8/2 cotton</td></tr>
</table>

23 Cotton Wraps and Servings

23.1 General

23.1.1 A cotton serving or wrap covering an insulated conductor shall be closely laid, shall result in the coverage indicated in 23.2.1, and shall be composed of cotton yarn of a size and ply not less than indicated in Table 23.1.

Table 23.1
Yarn for cotton wrap or serving

Diameter under serving		Minimum size and ply of yarn
inches	mm	
0 – 0.200	0 – 5.08	14/1
0.201 – 0.360	5.11 – 9.14	12/1
0.361 – 0.800	9.17 – 20.32	10/1
0.801 – 1.500	20.35 – 38.10	12/2

23.1.2 A cotton serving or wrap shall be constructed and applied to make the tangent of the lay angle (the angle between the yarn and the axis of the wire or cable) not less than indicated in Table 23.2.

Table 23.2
Cotton-wrap angle

Table 23.2 revised April 1, 2002

Diameter under wrap		Value of tangent	Corresponding lay angle in degrees
1.000 inch or less (25.40 mm or less)	14 – 9 AWG only	0.649	33
	All other wire sizes	0.700	35
1.001 – 1.500 inches (25.43 – 38.10 mm)		0.839	40

23.1.3 When a wrap consists of two or more servings, the lay of adjacent servings shall be in opposite directions and the angle of lay and coverage of any outer serving shall be based on the diameter over the serving immediately under the outer serving.

23.2 Coverage

23.2.1 The size, ply, and number of ends of yarn and the length of lay shall result in a wrap that covers at least 80 percent of the surface to which it is applied, when computed by means of whichever of the following formulas applies.

$$Q = \frac{100\,NW}{B_{in}}$$

$$Q = \frac{2540\,NW}{B_{mm}}$$

in which:

Q is the percent coverage,

N is the number of ends of yarn in the ribbon,

No Text on This Page

W is the constant for the yarn size employed (see Table 23.3),

B = C cos A = L sin A,

C is the mean circumference of the serving = L tan A,

L is the length of lay (measured), and

A is the lay angle.

23.2.2 With reference to 23.2.1 and Table 23.3, the value of C (the mean circumference of the wrap) is to be computed from the expression

$$C = \pi (D + T)$$

in which:

D is the nominal diameter of the wire over the insulation (under the wrap) and

T is the constant for the size of yarn employed (as given in Table 23.3).

The length of lay is to be measured using a sample of wire 20 – 24 inches or 500 – 600 mm long. When computed in this manner, the percent coverage is required to be at least 80 without any minus tolerance.

23.2.2 revised March 22, 1999

Table 23.3
Cotton-yarn constants

Size and ply of yarn (size/ply)	Values of constants		
	W	T	
		inch	mm
14/1	0.0134	0.0096	0.2438
12/1	0.0144	0.0105	0.2667
10/1	0.0158	0.0114	0.2896
12/2	0.0204	0.0155	0.3937

23.2.3 Binder threads of a fibrous material shall be helically applied to the outermost serving or wrap and in the direction opposite that of the lay of the yarns in that serving. The binder threads shall be uniformly spaced and shall consist of material having a strength, elasticity, and a manner of application that enable the completed wire or cable to withstand the cold-bend test in 47.1 without breaking any of the binder threads.

23.2.4 With reference to the moisture-absorption and cold-bend tests referenced in 46.1 and 47.1, the cold-bend test is to be conducted first (with adjacent turns in contact with one another). The specimen is then to be used for the moisture-absorption test with the helix elongated (after removal from the mandrel) to the point that adjacent turns are 1/8 – 1/4 inch or 3 – 6 mm apart.

24 Glass Wraps

24.1 A glass serving or wrap on an insulated conductor shall be closely laid, shall employ a glass yarn that is not smaller than 150-1/0, shall have an angle of lay in accordance with 23.1.2, shall provide the coverage specified in 23.2.1 and 23.2.2, and shall have binder threads in accordance with 23.2.3 and 23.2.4. A glass wrap shall not be used as an outer covering when the diameter under that covering is greater than 0.200 inch or 5.08 mm.

24.2 The coverage requirement in 24.1 is based on the use of 150-1/0 glass yarn, which is the size most generally used, and for which the yarn constant W is 0.010 inch for computing coverage by means of the formula in 23.2.1. The yarn constant T is 0.0040 inch or 0.1016 mm for computing the mean circumference by means of the formula in 23.2.2.

25 Spun-Rayon Braids and Wraps

25.1 A spun-rayon braid or wrap shall comply with the requirements for cotton coverings with No. 6 single-ply yarn or No. 12 2-ply yarn used when the diameter over the insulation (under the covering) is 0.801 – 1.500 inches or 20.35 – 38.10 mm.

25.1 revised March 22, 1999

26 Saturation of Fibrous Coverings Other Than Tapes

26.1 All fibrous coverings other than tapes shall be saturated and finished to enable the completed construction to comply with the moisture test described in 46.1.

26.2 The saturant and finish on a fibrous-covered single-conductor wire or cable and the saturant of the overall fibrous covering of a multiple-conductor assembly for use in armored cable shall enable the completed wire, cable, or assembly to comply with the horizontal flame test described in 53.1 and 53.2. The jacket or the saturant and any finish on a fibrous-covered individual wire for use in armored cable without a lead sheath under the armor shall enable the completed individual wire to comply with the horizontal flame test described in 53.1 and 53.2.

26.3 The saturant and any finish on a fibrous-covered individual wire of a multiple-conductor cable (cable that qualifies for the suffix letter ″D ″ or ″ M″ indicated in 60.40) is not required to enable the completed wire to comply when flame-tested.

26.3 revised March 22, 1999

26.4 The saturant and finish on a fibrous-covered multiple-conductor cable (cable that qualifies for the suffix letter ″D″ or ″M″ indicated in 60.40) is required to enable the completed cable to comply when flame-tested.

27 Finish

27.1 The surface of a fibrous covering on a wire or cable shall be smooth and shall not be tacky. The finish shall not flake off of the wire or cable during or as a result of the cold-temperature bending referenced in 47.1 without the surface of the wire actually being rubbed. Cracking not associated with flaking shall be disregarded.

28 Thicknesses of Jacket

28.1 The average and minimum thicknesses of a neoprene, NBR/PVC, CPE, or CP jacket shall not be less than indicated in the applicable Table 28.1, 28.2, 28.3, or 28.4 when determined as indicated in Thicknesses of Jacket on Thermoplastic- and Thermoset-Insulated Wires and Cables, Section 260 of UL 1581, or Thicknesses of Jacket on Flexible Cord, Fixture Wire, and Elevator Cable, Section 280 of UL 1581. Any reinforcement between the insulation and the jacket on a No. 1 AWG or larger conductor shall be a compound-filled tape or braid..

28.1 revised March 22, 1999

Table 28.1
Thicknesses of jacket on single-conductor wires and cables

Table 28.1 revised April 1, 2002

	600-V wires and cables				2000–V Wires and Cables			
	mils		mm		mils		mm	
Size of conductor	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 average thickness	Minimum thickness at any point
AWG								
14 – 12	15	12	0.38	0.30	15	12	0.38	0.30
11, 10	15	12	0.38	0.30	30	24	0.76	0.61
9 – 3	30	24	0.76	0.61	30	24	0.76	0.61
2	30	24	0.76	0.61	45	36	1.14	0.91
1 – 3/0	45	36	1.14	0.91	45	36	1.14	0.91
4/0	45	36	1.14	0.91	65	52	1.65	1.32
kcmil								
213 – 1000	65	52	1.65	1.32	65	52	1.65	1.32
1001 – 2000	95	76	2.41	1.93	95	76	2.41	1.93

Table 28.2
Thicknesses of jacket on each insulated conductor in 2-conductor flat parallel wire or cable, and in a cabled multiple-conductor cable or assembly

Calculated diameter of insulation under jacket		mils		mm	
inches	mm	Minimum average thickness of jacket[a]	Minimum thickness at any point of jacket[a]	Minimum average thickness of jacket[a]	Minimum thickness at any point of jacket[a]
0 – 0.250	0– 6.35	15	12	0.38	0.30
0.251 – 0.425	6.38 – 10.80	25	20	0.64	0.51
0.426 – 0.700	10.82 – 17.78	30	24	0.76	0.61
0.701 – 1.500	17.81 – 38.10	50	40	1.27	1.02
1.501 – 2.500	38.13 – 63.50	80	64	2.03	1.62

[a]Not applicable to a colored coating on an insulated conductor.

Table 28.3
Thicknesses of overall jacket on 600-V[a] 2-conductor flat parallel wire or cable

Table 28.3 revised July 13, 2000

Size of conductors	mils		mm	
	Minimum average thickness of jacket	Minimum thickness at any point of jacket	Minimum average thickness of jacket	Minimum thickness at any point of jacket
14 – 11 AWG	45	36	1.14	0.91
10 – 5	60	48	1.52	1.22
4 – 4/0	80	64	2.03	1.62
213 – 2000 kcmil	a	a	a	a

[a]For 600-V 2-conductor flat parallel cable larger than No. 4/0 AWG and for any size of 2-conductor flat parallel wire or cable rated for 2000-V the jacket thicknesses in Table 28.4 apply.

Table 28.4
Thicknesses of overall jacket on cabled multiple-conductor cable, on 600-V 2-conductor flat parallel cable larger than No. 4/0 AWG, and on all sizes of 2000-V 2-conductor flat parallel wire or cable

Calculated diameter under jacket of round cable and calculated length of major axis under jacket of 2-conductor flat parallel cable not covered by Table 28.3		mils		mm	
inches	mm	Minimum average thickness of jacket	Minimum thickness at any point of jacket	Minimum average thickness of jacket	Minimum thickness at any point of jacket
0 – 0.425	0 – 10.80	45	36	1.14	0.91
0.426 – 0.700	10.82 – 17.78	60	48	1.52	1.22
0.701 – 1.500	17.81 – 38.10	80	64	2.03	1.62
1.501 – 2.500	38.13 – 63.50	110	88	2.79	2.23
over 2.500	over 63.50	140	112	3.56	2.85

29 Lubrication

29.1 Each finished wire or cable shall be coated with talc dust, mica dust, or another lubricant that facilitates pulling the wire or cable into conduit unless the results of an investigation demonstrate that the wire or cable is self-lubricating to keep it from being damaged when pulled into conduit. Wires and cables intended for further processing (for use as the individual insulated conductors of a service-entrance cable, for example); assemblies of wires for use in armored cable or as pump cable; and the assemblies covered in 34.1 are not required to be lubricated.

29.1 revised March 22, 1999

METAL COVERINGS

30 General

Section 30 deleted March 22, 1999

31 Lead Sheath

Section 31 deleted March 22, 1999

32 Aluminum Sheath

Section 32 deleted March 22, 1999

LAY OF CABLED CONDUCTORS

33 General

33.1 The two or more conductors in a multiple-conductor round cable or assembly other than the assemblies covered in 34.1 and the pump cable covered in Cable for Deep-Well Submersible Water Pumps, General, Section 35, shall be cabled with a length of lay not greater than indicated in Table 33.1. In a cable consisting of a number of layers of conductors, the direction of lay of successive layers shall be reversed, with the outer layer in any case having a left-hand lay (counter-clockwise away from the observer).

Table 33.1
Length of lay of cabled conductors other than the assemblies and pump cables covered in Sections 34 and 35

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

[a] "Conductor diameter" is the calculated diameter of one of the individual finished conductors of which the cable is composed.

ASSEMBLIES THAT INCLUDE SINGLE-CONDUCTOR THERMOSET-INSULATED WIRES

34 General

34.1 Single-conductor wires that individually comply with the requirements in this Standard, with or without including other insulated single-conductor cables, are to be cabled (length and direction of lay not specified) into assemblies (not to be identified as cables) without overall coverings, other than an open, skeleton tape or wrap intended only to hold the assembly together. A grounding conductor is not required. The size of any grounding conductor used is not specified. An insulated grounding conductor shall be of solid or stranded copper, aluminum, or copper-clad aluminum. A bare grounding conductor shall not be covered and shall be of solid copper coated with tin or a tin/lead alloy. The completed assembly shall comply with the following requirements:

a) Assemblies in which bare coated copper conductor is included are to be tank tested (dielectric voltage-withstand) as indicated in 36.1 after immersion in water for at least 1 h (at least 6 h when any 2000-V conductor is included).

b) Each assembly in which a bare conductor is not included is either to be tank tested (1- or 6-h or longer immersion) as indicated in 36.1 or spark tested as indicated in 41.1 (each layer in a multiple- layer assembly is to be sparked separately).

c) Each 14 – 8 AWG conductor in an assembly is to be individually tested for continuity after the assembly is completed.

34.1 revised April 1, 2002

CABLE FOR DEEP-WELL SUBMERSIBLE WATER PUMPS

35 General

35.1 The circuit conductors in a cable for use within well casings for wiring deep-well submersible water pumps shall consist of solid or stranded 14 – 2 AWG copper, solid or stranded 12 – 2 AWG aluminum or copper-clad aluminum, or stranded 1 AWG – 500 kcmil copper or aluminum or copper-clad aluminum Type RHW-2, XHHW-2, RHW, or XHHW conductors. A grounding conductor is not required. Where used, a grounding conductor shall consist of a fully insulated solid or stranded conductor that is of the same type as the circuit conductors, is of a size that is not smaller than indicated in Table 35.1 or 35.2 for the largest size circuit conductor used, and is identified as indicated in 60.27. The insulation shall comply with 14.1. See 14.3 for the long-term evaluation of an insulation or jacket material not named in Table 5.1 or 5.2 or not complying with the short-term tests specified for the material in Specific Materials, Section 50 of UL 1581. The circuit and grounding conductors shall be assembled in one of the following ways:

a) Two through six circuit conductors plus any grounding conductor are to be cabled (length of lay not specified) with an overall covering. The overall covering shall consist of a neoprene, NBR/PVC, CPE, or CP jacket having the thicknesses in Table 35.3 for the largest size circuit conductor used and the physical properties in the applicable Table 50.112, 50.87, 50.31, or 50.10 of UL 1581.

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

c) Two or three circuit conductors plus any grounding conductor are to be laid flat and parallel to one another with an interconnecting web between adjacent conductors extruded simultaneously with the insulation, integral insulation and jacket, or jacket. Polarity identification

of each circuit conductor shall be present and shall consist of ridges, surface striping, or word printing. The minimum thickness at any point of the insulation, integral insulation and jacket, or jacket on each circuit conductor and any grounding conductor after separation shall not be less than the minimum thickness at any point indicated in Tables 15.3, 15.4, or 28.1 for the insulation, integral insulation and jacket, or jacket of single-conductor Type RHW-2, XHHW-2, RHW, or XHHW wire of the same construction.

d) Two or three circuit conductors plus any grounding conductor are to be laid flat and parallel to one another with a nonintegral, overall neoprene, NBR/PVC, CPE, or CP jacket having the thicknesses in Table 35.3 and the physical properties in Table 50.112, 50.87, 50.31, or 50.10 of UL 1581. There shall be an interconnecting web between adjacent conductors. The web shall be integral with the jacket. The thickness of the web is not specified.

35.1 revised April 1, 2002

Table 35.1
Smallest size of grounding conductor, where used, in deep-well submersible-water-pump cable with all conductors of copper

Table 35.1 revised March 22, 1999

Size of circuit conductors	Smallest AWG size of grounding conductor	
	Type RHW-2 or XHHW-2	Type RHW or XHHW
AWG		
14	14	14
13	13	13
12	12	12
11	11	11
10 – 8	10	10
7 – 4	8	8
3	6	8
2 – 2/0	6	6
3/0	4	6
4/0 – 250 kcmil	4	4
251 – 300	3	4
301 – 400	3	3
401 – 500	2	3

Table 35.2
Smallest size of grounding conductor, where used, in deep-well submersible-water-pump cable with all conductors of aluminum or copper-clad aluminum

Table 35.2 revised March 22, 1999

Size of circuit conductors	Smallest AWG size of grounding conductor	
	Type RHW-2 or XHHW-2	Type RHW or XHHW
AWG		
12	12	12
11	11	11
10	10	10
9	9	9
8 – 6	8	8
5	6	8
4 – 2	6	6
1	4	6
1/0 – 3/0	4	4
4/0	2	4
kcmil		
213 – 350	2	2
351 – 400	1	2
401 – 500	1	1

Table 35.3
Nonintegral jacket on pump cable

Table 35.3 revised March 22, 1999

Conductor size	Minimum average thickness of jacket		Minimum thickness at any point of jacket	
	mils	mm	mils	mm
14 – 10 AWG	15	0.38	12	0.30
9 – 2	30	0.76	24	0.61
1 – 4/0	45	1.14	36	0.91
213 – 500 kcmil	65	1.65	52	1.32

PERFORMANCE

DIELECTRIC VOLTAGE-WITHSTAND TEST IN WATER

36 General

36.1 The insulation shall enable a finished wire or cable capable to withstand for 60 s without breakdown the application of the test potential indicated in Table 36.1 under the following conditions. The wire or cable shall be immersed in tap water at room temperature for not less than 6 h, following which it shall be subjected to the voltage test while still immersed. The dielectric voltage-withstand test shall be conducted before the insulation-resistance test. The test is to be made as described in Dielectric Voltage-Withstand Test of Coils and Reels in Water, Section 820 of UL 1581. See also 41.1.

36.1 revised March 22, 1999

Table 36.1
48 – 62 Hz RMS dielectric test potential in kilovolts

Table 36.1 revised April 1, 2002

Size of Conductor	600-V Type SIS	600-V Types XHHW-2, XHHW, XHH, RHW-2, RHH, RHW, and SA	2000-V Types RHW-2, RHH, and RHW
14 – 12 AWG	3.0	3.0	6.0
11, 10	3.0	3.0	6.0
9, 8	3.5	3.5	6.0
7	3.5	3.5	7.5
6 – 2	3.5	3.5	7.5
1 – 4/0	4.0	4.0	9.0
213 – 500 kcmil	–	5.0	10.0
501 – 1000	–	6.0	11.0
1001 – 2000	–	7.0	13.5

36.2 The test voltage is to be applied before or after any fibrous covering or jacket is applied or before any finishing operation, however, not before the cross-linking process. The water is to be at any convenient temperature, and no adjustment multiplier is necessary.

36.3 The individual conductors of a multiple-conductor cable are to be tested in tap water before assembly. After assembly, the test potential is to be applied between each conductor and all of the other conductors connected together.

36.3 revised March 22, 1999

TEST FOR INSULATION RESISTANCE AT 60.0°F (15.6°C)

37 General

37.1 The insulation shall result in the finished wire or cable having an insulation resistance of not less than the number of megohms, based on a thousand conductor feet, indicated in Table 37.1 (600-V wire or cable) or 37.2 (2000-V wire or cable) or not less than the number of megohms, based on a conductor kilometer, indicated in Table 37.3 (600-V wire or cable) or 37.4 (2000-V wire or cable) when the wire or cable is tested under the following conditions: the wire or cable shall be immersed in tap water at 60.0°F (15.6°C) for not less than 6 h, following which it shall be tested for insulation resistance while still immersed, except that metal-sheathed cable is not required to be immersed in water. This test is to be conducted immediately following the dielectric voltage-withstand test and, in any case, the coil or coils shall be earth-grounded and completely discharged previous to the measurement of insulation resistance. The test is to be made as described in Insulation-Resistance Test in Water, Section 920 of UL 1581.

Table 37.1
Minimum insulation resistance of 600-V wires and cables in megohms based on 1000 conductor feet at 60.0°F (15.6°C)

Table 37.1 revised July 13, 2000

Size of conductor	Type SA wire with insulation as indicated in Table 15.1	Type XHHW-2, XHHW, and XHH wires with insulation as indicated in Table 15.3	Type SIS wire with Class EPCV, CP, CPE, or XL insulation as indicated in Table 15.2	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.4				
				Wire with insulation consisting of:				
				SBR/ IIR/NR	Class CP or CPE	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
AWG								
14	760	2875	285	1525	380	3820	3820	1525
13	710	2670	265	1420	355	3560	3560	1405
12	650	2430	240	1305	325	3280	3280	1295
11	600	2225	220	1200	300	3010	3010	1190
10	550	2010	200	1105	275	2765	2765	1095
9	625	2550	255	1255	310	3135	3135	1245
8	520	2095	205	1040	260	2600	2600	1040
7	475	1900	190	950	235	2380	2380	950
6	435	1730	170	870	215	2175	2600	870
5	395	1580	155	795	195	1985	2380	795
4	360	1430	140	725	180	1815	2175	720
3	325	1300	125	655	160	1640	1985	655
2	295	1170	115	595	145	1490	1790	595
1	340	1235	120	680	170	1700	2040	680
1/0	310	1105	110	620	155	1550	1875	685
2/0	280	1000	100	560	140	1395	1700	560
3/0	250	895	90	505	125	1270	1550	505
4/0	225	825	80	455	110	1135	1395	455

Table 37.1 Continued on Next Page

Table 37.1 Continued

Size of conductor	Type SA wire with insulation as indicated in Table 15.1	Type XHHW-2, XHHW, and XHH wires with insulation as indicated in Table 15.3	Type SIS wire with Class EPCV, CP, CPE, or XL insulation as indicated in Table 15.2	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.4				
				Wire with insulation consisting of:				
				SBR/ IIR/NR	Class CP or CPE	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
kcmil								
250	245	895	–	495	120	1235	1610	495
300	225	825	–	455	110	1135	1490	455
350	210	755	–	425	105	1070	1395	425
400	200	715	–	400	100	1000	1335	400
450	190	680	–	385	95	965	1270	380
500	180	645	–	360	90	895	1205	365
550	200	755	–	400	100	1000	1270	395
600	190	715	–	385	95	965	1205	380
650	185	680	–	370	90	930	1170	365
700	180	680	–	360	90	895	1135	355
750	170	645	–	345	85	860	1105	345
800	165	645	–	330	80	825	1070	335
900	155	605	–	315	75	790	1035	315
1000	150	565	–	300	75	755	965	300
1100	165	645	–	330	80	825	–	325
1200	155	605	–	315	75	790	–	310
1250	150	605	–	300	75	755	–	305
1300	150	565	–	300	75	755	–	300
1400	140	565	–	285	70	715	–	290
1500	140	530	–	285	70	715	–	280
1600	135	530	–	270	65	680	–	270
1700	135	530	–	270	65	680	–	265
1750	125	490	–	255	65	645	–	260
1800	125	490	–	255	65	645	–	255
1900	125	490	–	255	65	645	–	250
2000	120	490	–	240	60	605	–	245

Table 37.2
Minimum insulation resistance of 2000-V wires and cables in megohms based on 1000 conductor feet at 60°F (15.6°C)

Table 37.2 revised April 1, 2002

Size of conductor	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.5				
	Wire with insulation consisting of Class EP, EPCV, or XL	Wire with insulation consisting of Class CP or CPE	Wire with insulation consisting of Class SBR/IIR/NR	Wire with insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
AWG					
14	4590	540	2175	4590	1830
13	4295	510	2045	4295	1700
12	3975	475	1905	3975	1575
11	3670	440	1775	3670	1460
10	3400	410	1645	3400	1350
9	3500	380	1535	3500	1390
8	2920	320	1285	3345	1165
7	2670	295	1185	3095	1070
6	2450	305	1230	2830	980
5	2250	280	1130	2625	900
4	2040	260	1040	2380	815
3	1875	235	950	2175	745
2	1700	215	870	1985	680
1	1875	220	880	2200	750
1/0	1700	200	805	2010	680
2/0	1550	185	735	1845	620
3/0	1395	165	665	1670	560
4/0	1270	150	605	1520	505
kcmil					
250	1365	155	630	1730	540
300	1235	145	580	1580	495
350	1170	135	545	1490	465
400	1105	125	505	1395	435
450	1035	120	480	1335	415
500	1000	115	465	1270	395
550	1070	120	495	1335	430
600	1035	115	465	1300	410
650	1000	110	455	1235	395
700	965	110	440	1205	386
750	930	105	425	1170	370
800	895	100	415	1135	360

Table 37.2 Continued on Next Page

Table 37.2 Continued

Size of conductor	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.5				
	Wire with insulation consisting of Class EP, EPCV, or XL	Wire with insulation consisting of Class CP or CPE	Wire with insulation consisting of Class SBR/IIR/NR	Wire with insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
900 kcmil	860	100	400	1070	340
1000	825	90	370	1035	325
1100	905	90	360	1295	360
1200	865	85	345	1250	345
1250	850	85	340	1225	340
1300	840	85	335	1205	335
1400	810	80	325	1165	325
1500	785	80	315	1130	315
1600	760	75	305	1100	305
1700	740	74	295	1070	295
1750	730	70	290	1055	290
1800	720	70	290	1040	290
1900	705	70	280	1020	280
2000	685	70	275	990	275

Table 37.3
Minimum insulation resistance of 600-V wires and cables in megohms based on conductor kilometer at 60.0°F (15.6°C)

Table 37.3 revised April 1, 2002

Size of conductor	Type SA wire with insulation as indicated in Table 15.1	Type XHHW-2, XHHW, and XHH wires with insulation as indicated in Table 15.3	Type SIS wire with Class EPCV , CP, CPE, or XL insulation as indicated in Table 15.4	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.4				
				Wire with insulation consisting of:				
				SBR/ IIR/NR	Class CP or CPE	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
AWG								
14	235	880	90	465	120	1165	1165	460
13	220	815	85	435	110	1085	1085	425
12	200	745	75	400	100	1005	1005	390
11	185	680	70	370	95	920	920	360
10	170	615	65	340	85	845	845	330
9	190	780	80	385	95	960	960	375
8	160	640	65	320	80	795	795	315
7	145	580	60	290	75	725	725	285

Table 37.3 Continued on Next Page

Table 37.3 Continued

Size of conductor	Type SA wire with insulation as indicated in Table 15.1	Type XHHW-2, XHHW, and XHH wires with insulation as indicated in Table 15.3	Type SIS wire with Class EPCV , CP, CPE, or XL insulation as indicated in Table 15.4	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.4				
				Wire with insulation consisting of:				
				SBR/ IIR/NR	Class CP or CPE	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
6 AWG	135	530	55	265	70	665	795	265
5	125	485	50	245	60	605	725	240
4	115	440	45	225	55	555	665	215
3	100	400	40	205	50	500	605	195
2	95	360	40	185	45	455	550	180
1	105	380	40	210	50	520	625	205
1/0	95	340	35	190	50	475	575	205
2/0	85	310	35	175	45	425	520	170
3/0	80	275	30	155	40	390	475	150
4/0	70	255	25	140	35	450	430	135
kcmil								
250	80	275	–	155	40	380	495	150
300	70	255	–	140	35	350	455	135
350	65	230	–	135	35	330	430	125
400	65	220	–	125	30	305	410	120
450	60	210	–	120	30	295	390	115
500	55	200	–	110	30	275	370	110
550	65	230	–	125	30	305	390	120
600	60	220	–	120	30	295	370	115
650	60	210	–	115	30	285	360	110
700	55	210	–	110	30	275	350	105
750	55	200	–	105	30	265	340	105
800	55	200	–	105	25	255	330	100
900	50	185	–	100	25	245	320	95
1000	50	175	–	95	75	230	295	90
1100	55	200	–	105	25	255	–	95
1200	50	185	–	100	25	245	–	90
1250	50	185	–	95	25	230	–	90
1300	50	175	–	95	25	230	–	90
1400	45	175	–	90	25	220	–	85
1500	45	165	–	90	25	220	–	85
1600	45	165	–	85	20	210	–	80
1700	45	165	–	85	20	210	–	80
1750	40	150	–	80	20	200	–	75

Table 37.3 Continued on Next Page

Table 37.3 Continued

Size of conductor	Type SA wire with insulation as indicated in Table 15.1	Type XHHW-2, XHHW, and XHH wires with insulation as indicated in Table 15.3	Type SIS wire with Class EPCV , CP, CPE, or XL insulation as indicated in Table 15.4	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.4				
				Wire with insulation consisting of:				
				SBR/ IIR/NR	Class CP or CPE	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
1800 kcmil	40	150	–	80	20	200	–	75
1900	40	150	–	80	20	200	–	75
2000	40	150	–	75	20	200	–	70

Table 37.4
Minimum insulation resistance of 2000-V wires and cables in megohms based on a conductor kilometer at 60.0°F (15.6°C)

Table 37.4 revised April 1, 2002

Size of conductor	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.5				
	Wire with insulation consisting of Class EP, EPCV, or XL	Wire with insulation consisting of Class CP or CPE	Wire with insulation consisting of Class SBR/IIR/NR	Wire with insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
AWG					
14	1400	165	665	1400	555
13	1310	155	625	1310	515
12	1215	145	585	1215	480
11	1120	135	545	1120	440
10	1040	125	505	1040	410
9	1070	120	470	1070	420
8	895	100	395	1020	355
7	815	90	365	945	325
6	750	95	375	865	295
5	690	85	345	800	270
4	625	80	320	725	245
3	575	75	290	665	225
2	520	70	265	605	205
1	575	70	270	675	225
1/0	520	65	245	615	205
2/0	475	60	225	565	185
3/0	430	50	205	510	170
4/0	390	50	185	465	150

Table 37.4 Continued on Next Page

Table 37.4 Continued

Size of conductor	Type RHW-2, RHH, and RHW wires with insulation as indicated in Table 15.5				
	Wire with insulation consisting of Class EP, EPCV, or XL	Wire with insulation consisting of Class CP or CPE	Wire with insulation consisting of Class SBR/IIR/NR	Wire with insulation consisting of a layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
250 kcmil	420	50	195	530	160
300	380	45	180	485	150
350	360	45	170	455	140
400	340	40	155	425	130
450	320	40	150	410	125
500	310	35	145	390	120
550	330	40	155	410	130
600	320	35	145	400	125
650	310	35	140	380	120
700	295	35	135	370	115
750	285	35	130	360	110
800	275	30	130	350	105
900	265	30	125	330	100
1000	255	30	115	315	95
1100	275	30	110	390	110
1200	265	25	105	380	105
1250	260	25	105	370	105
1300	255	25	100	365	100
1400	245	25	100	355	100
1500	240	25	95	345	95
1600	230	20	90	335	90
1700	225	20	90	325	90
1750	220	20	90	320	90
1800	220	20	90	315	90
1900	215	20	85	310	85
2000	210	20	85	300	85

38 Temperature Factor

38.1 The temperature of the water in which the coil is immersed has a marked effect upon the insulation resistance. When the temperature at which the readings are taken (see 920.2 of UL 1581) is other than 60.0°F (15.6°C), the readings are to be multiplied by the applicable multiplying factor M from Table 38.1. Where the column of factors in Table 38.1 is shown not to fit a particular insulation material, an applicable column of M values is to be determine by means of the method described in Test Procedure for Determining the Multiplying-Factor Column for Adjusting Insulation Resistance, Section 919 of UL 1581.

38.1 revised April 1, 2002

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Table 38.1
Factor for adjusting insulation resistance to 60.0°F (15.6°C)

Temperature[a]		
°F	°C	Multiplying factor M
50	10.0	0.73
51	10.6	0.76
52	11.1	0.78
53	11.7	0.80
54	12.2	0.83
55	12.8	0.86
56	13.3	0.88
57	13.9	0.91
58	14.4	0.94
59	15.0	0.97
60	15.6	1.00
61	16.1	1.03
62	16.7	1.07
63	17.2	1.10
64	17.8	1.13
65	18.3	1.17
66	18.9	1.20
67	19.4	1.24
68	20.0	1.28
69	20.6	1.32
70	21.1	1.36
71	21.7	1.40
72	22.2	1.45
73	22.8	1.50
74	23.3	1.55
75	23.9	1.59
76	24.4	1.64
77	25.0	1.69
78	25.6	1.75
79	26.1	1.80
80	26.7	1.86

Table 38.1 Continued on Next Page

Table 38.1 Continued

Temperature[a]		
°F	°C	Multiplying factor M

[a]The temperature of the water in which the coil or coils are immersed at the time that the insulation-resistance readings are taken is the basis for selection of the multiplying factor. When, because of hot or cold weather or local conditions, the temperature of the insulation to be tested differs by more than 5.0°F (2.8°C) from the temperature of the water in which the insulation is to be immersed, the test results after a 6-h immersion are not accurate unless one of the following is accomplished before insulation-resistance readings are taken:

a) The wire is to be in the water for whatever time it takes for the conductor, insulation, and any other parts of the complete wire to attain the same temperature as the water. The water and the wire immersed in it are at the same temperature when three successive measurements of the d-c resistance of the conductor made at 30-min intervals by means of the equipment indicated in 220.1 of UL 1581 show no change.

b) The water is to be heated or cooled to within 5.0°F (2.8°C) of the temperature of the wire before the wire is immersed for at least 6 h.

TEST FOR INSULATION RESISTANCE IN WATER AT RATED TEMPERATURE

39 General

39.1 Minimum value

39.1.1 The insulation on Type XHHW-2, XHHW, RHW-2, and RHW wires shall result in the finished wire having an insulation resistance in tap water at elevated temperature that is not less than indicated in Table 39.1 (megohms based on 1000 conductor feet) or in Table 39.2 (megohms based on a conductor kilometer) at any time during immersion under the following conditions. The temperature of the water shall be 75°C (167°F) for Type RHW and XHHW wires, and it shall be 90°C (194°F) for Type RHW-2 and XHHW-2 wires. The period of immersion shall be 12 weeks or more when the insulation resistance throughout the last 6 weeks of the period is higher than 10 megohms based on 1000 conductor feet or is higher than 3 megohms based on a conductor kilometer. The period of immersion shall be 24 – 36 weeks when the insulation resistance is less than 10 megohms based on 1000 conductor feet and equals or exceeds the value indicated in Table 39.1 or is less than 3 megohms based on a conductor kilometer and equals or exceeds the value indicated in Table 39.2. A sinusoidal or nearly sinusoidal rms potential equal to the voltage rating of the wire (600 V or 2000 V) at 48 – 62 Hz shall be applied to the insulation at all times other than while readings of insulation resistance are being taken. See also 39.2.1 for the requirement covering the maximum rate of decrease of the insulation resistance.

Table 39.1
Minimum long-time insulation resistance of Type XHHW-2, RHW-2, XHHW, and RHW wires in megohms based on 1000 conductor feet at rated temperature

Table 39.1 revised March 22, 1999

AWG size of conductor	Type XHHW-2 [a] and XHHW[b] wires with insulation as indicated in Table 15.3	600-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.4			2000-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.5		
		Wire with insulation consisting of:			Wire with insulation consisting of:		
		Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV,or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP
14	0.180	0.095	0.240	0.240	0.135	0.290	0.290
13	0.170	0.090	0.225	0.225	0.130	0.270	0.270
12	0.155	0.080	0.205	0.205	0.120	0.250	0.250
11	0.140	0.075	0.190	0.190	0.110	0.230	0.230
10	0.125	0.070	0.175	0.175	0.105	0.215	0.215
9	0.160	0.080	0.200	0.200	0.095	0.220	0.220
8	0.130	0.065	0.165	0.165	0.080	0.185	0.210
7	0.120	0.060	0.150	0.150	0.075	0.170	0.195
6	0.110	0.055	0.135	0.165	0.075	0.155	0.180
5	0.100	0.050	0.125	0.150	0.070	0.140	0.165
4	0.090	0.045	0.115	0.135	0.065	0.130	0.150
3	0.080	0.040	0.105	0.125	0.060	0.115	0.135
2	0.075	0.035	0.095	0.110	0.055	0.105	0.125
1	0.075	0.040	0.105	0.130	0.055	0.115	0.140
1/0	0.070	0.040	0.100	0.115	0.050	0.105	0.125
2/0	0.060	0.035	0.085	0.105	0.045	0.095	0.115
3/0	0.055	0.030	0.080	0.095	0.040	0.085	0.105
4/0	0.050	0.025	0.070	0.090	0.035	0.080	0.095

[a] Water at 90°C (194°F) for Type XHHW-2 and RHW-2 wires.
[b] Water at 75°C (167°F) for Type XHHW and RHW wires.

39.1.2 The values in Tables 39.1 and 39.2 apply only to Type XHHW and XHHW-2 wires and to 600-V and 2000-V Type RHW and RHW-2 wires with insulations of the materials and in the thicknesses indicated in Tables 15.3 (Type XHHW and XHHW-2), 15.4 (600-V Type RHW and RHW-2), and 15.5 (2000-V Type RHW and RHW-2). For other thicknesses of the same materials and for other materials in any thickness, the insulation-resistance values are to be calculated by means of whichever of the following formulas is applicable

$$IR_{75°C\ or\ 90°C} = K_{15.6°C} \times 6.37 \times 10^{-5} \times \log_{10} \frac{D}{d}$$

in which:

IR at 75°C (167°F) or at 90°C (194°F) is the insulation resistance in megohms based on 1000 conductor feet at the wet-locations rated temperature of the wire,

K is the constant for the insulation material at 60.0°F (15.6°C) in megohms based on 1000 conductor feet, 6.37 x 10^{-5} is the multiplier for reducing K at 60.0°F (15.6°C) to the value it would have at 75°C (167°F) or 90°C (194°F),

D is the diameter over the insulation in inches, and

d is the diameter of the metal conductor in inches; or

$$IR_{75°C\ or\ 90°C} = K_{15.6°C} \times 1.94 \times 10^{-5} \times \log_{10} \frac{D}{d}$$

in which:

IR at 75°C (167°F) or 90°C (194°F) is the insulation resistance in megohms based on a conductor kilometer at the wet-locations rated temperature of the wire,

K is the constant for the insulation material at 60.0°F (15.6°C) in megohms based on 1000 conductor feet, 1.94 x 10^{-5} is the multiplier for reducing K at 60.0°F (15.6°C) in megohms based on 1000 conductor feet to the value it would have at 75°C (167°F) or 90°C (194°F) in megohms based on a conductor kilometer,

D is the diameter over the insulation in millimeters, and

d is the diameter of the metal conductor in millimeters.

39.1.3 The extended immersion at 75°C (167°F) or 90°C (194°F) is an accelerated test for Type RHW and RHW-2 wires and for Type XHHW-2 and XHHW wires. Although these products are rated for use in wet locations at 75°C (167°F) or 90°C (194°F), it is not expected that the wires during service are exposed simultaneously to a temperature of 75°C (167°F) or 90°C (194°F) and water for long periods of time.

39.2 Maximum rate of decrease

39.2.1 The insulation indicated in 39.1.1 shall also have the effect that, during the extended immersion of Type RHW or XHHW wire at 75°C (167°F) or of Type XHHW-2 or RHW-2 wire at 90°C (194°F), the maximum decrease in insulation resistance per week, as determined from a curve (drawn to represent the average of actual values), for every continuous period of 3 weeks during the latter half of the specified immersion time, is not more than 4 percent when the insulation resistance on the basis of 1000 conductor feet is 10 megohms or more (3 megohms or more based on a conductor kilometer); and is not more than 2 percent when the insulation resistance is less than 10 but more than the value indicated in Table 39.1 (less than 3 megohms and more than the value indicated in Table 39.2).

39.3 Test method

39.3.1 To determine whether or not the insulation complies with the requirements in 39.1.1 and 39.2.1, the insulation is to be tested with the apparatus and according to the methods described in Insulation-Resistance Test in Water, Section 920 of UL 1581. The ends of a specimen are to be brought well away from the tank, and the temperature of the water is to be maintained at 75.0 ±1.0°C (167.0 ±1.8°F). A coil that shows a greater percent decrease in insulation resistance during the extended immersion than specified in 39.2.1 shall be tested for additional 1-week immersion periods and judged on the basis of the results for every continuous period of 3 weeks during the last 12 weeks of immersion. In each such case, the final insulation resistance is not to be less than specified in the appropriate Table 39.1 or 39.2.

Table 39.2
Minimum long-time insulation resistance of Type XHHW-2, RHW-2, XHHW, and RHW wires in megohms based on a conductor kilometer at rated temperature

Table 39.2 revised March 22, 1999

AWG size of conductor	Type XHHW-2 [a] and XHHW [b] wires with insulation as indicated in Table 15.3	600-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.4			2000-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.5		
		Wire with insulation consisting of:			Wire with insulation consisting of:		
		Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Class CP, CPE, or SBR/ IIR/Nr	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP
14	0.060	0.030	0.075	0.075	0.045	0.090	0.090
13	0.055	0.030	0.070	0.070	0.040	0.085	0.085
12	0.050	0.025	0.065	0.065	0.040	0.080	0.080
11	0.045	0.025	0.060	0.060	0.035	0.075	0.075
10	0.040	0.025	0.055	0.055	0.035	0.070	0.070
9	0.050	0.025	0.065	0.065	0.030	0.070	0.070
8	0.045	0.020	0.055	0.055	0.025	0.060	0.065
7	0.040	0.020	0.050	0.050	0.025	0.055	0.065
6	0.035	0.020	0.045	0.055	0.025	0.050	0.055
5	0.035	0.015	0.040	0.050	0.025	0.045	0.055
4	0.030	0.015	0.035	0.045	0.020	0.040	0.050
3	0.025	0.015	0.035	0.040	0.020	0.040	0.045
2	0.025	0.015	0.030	0.035	0.020	0.035	0.040
1	0.025	0.015	0.035	0.040	0.020	0.040	0.045

Table 39.2 Continued on Next Page

Table 39.2 Continued

AWG size of conductor	Type XHHW-2 [a] and XHHW [b] wires with insulation as indicated in Table 15.3	600-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.4			2000-V Type RHW-2 [a] and RHW [b] wires with insulation as indicated in Table 15.5		
		Wire with insulation consisting of:			Wire with insulation consisting of:		
		Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Class CP, CPE, or SBR/ IIR/Nr	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP
1/0	0.025	0.015	0.030	0.040	0.020	0.035	0.040
2/0	0.020	0.015	0.030	0.035	0.015	0.030	0.040
3/0	0.020	0.010	0.025	0.030	0.015	0.030	0.035
4/0	0.020	0.010	0.025	0.030	0.015	0.025	0.030

[a] Water at 90°C (194°F) for Type XHHW-2 and RHW-2 wires.
[b] Water at 75°C (167°F) for Type XHHW and RHW wires.

TEST FOR INSULATION RESISTANCE IN AIR AT 97.0°C (206.6°F)

40 General

40.1 Minimum value

40.1.1 The insulation on Type XHHW, XHH, and RHH wires shall have the effect that the finished wire with a snug-fitting close-weave outer braid of copper applied over the insulation has an insulation resistance in air at 97.0 ±1.0°C (206.6 ±1.8°F) that is not less than indicated in Table 40.1 (megohms based on 1000 conductor feet) or in Table 40.2 (megohms based on a conductor kilometer) at any time during an extended period in a full-draft circulating- air oven under the following conditions. The period in the oven shall be 12 weeks or more when the insulation resistance throughout the last 6 weeks of the period is higher than 10 megohms based on 1000 conductor feet or is higher than 3 megohms based on a conductor kilometer. The period in the oven shall be 24 – 36 weeks when the insulation resistance is less than 10 megohms based on 1000 conductor feet and equals or exceeds the value indicated in Table 40.1 or is less than 3 megohms based on a conductor kilometer and equals or exceeds the value indicated in Table 40.2. A sinusoidal or nearly sinusoidal rms potential of 600-V at 48 – 62 Hz shall be applied to the insulation at all times other than while readings of insulation resistance are being taken. See also 40.2.1 for the requirement covering the maximum rate of decrease of the insulation resistance.

40.1.1 revised March 22, 1999

Table 40.1
Minimum long-time insulation resistance of Type XHHW, XHH, and RHH wires in megohms based on 1000 conductor feet at 97.0°C (206.6°F)

Table 40.1 revised July 13, 2000

AWG size of conductor	Type XHHW and XHH wires with insulation as indicated in Table 15.3	600-V Type RHH wire with insulation as indicated in Table 15.4				2000-V Type RHH wire with insulation as indicated in Table 15.5			
		Wire with insulation consisting of:				Wire with insulation consisting of:			
		Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV,or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation	Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulataion
14	0.180	0.095	0.240	0.240	0.095	0.135	0.290	0.290	0.025
13	0.170	0.090	0.225	0.225	0.085	0.130	0.270	0.270	0.025
12	0.155	0.080	0.205	0.205	0.080	0.120	0.250	0.250	0.020
11	0.140	0.075	0.190	0.190	0.075	0.110	0.230	0.230	0.020
10	0.125	0.070	0.175	0.175	0.065	0.105	0.215	0.215	0.015
9	0.160	0.080	0.200	0.200	0.075	0.095	0.220	0.220	0.020
8	0.130	0.065	0.165	0.165	0.065	0.080	0.185	0.210	0.015
7	0.120	0.060	0.150	0.150	0.060	0.075	0.170	0.195	0.015
6	0.110	0.055	0.135	0.165	0.055	0.075	0.155	0.180	0.015
5	0.100	0.050	0.125	0.150	0.050	0.070	0.140	0.165	0.015
4	0.090	0.045	0.115	0.135	0.045	0.065	0.130	0.150	0.010
3	0.080	0.040	0.105	0.125	0.040	0.060	0.115	0.135	0.010
2	0.075	0.035	0.095	0.110	0.035	0.055	0.105	0.125	0.010
1	0.075	0.040	0.105	0.130	0.040	0.055	0.115	0.140	0.010
1/0	0.070	0.040	0.100	0.115	0.040	0.050	0.105	0.125	0.010
2/0	0.060	0.035	0.085	0.105	0.035	0.045	0.095	0.115	0.010
3/0	0.055	0.030	0.080	0.095	0.030	0.040	0.085	0.105	0.005
4/0	0.050	0.025	0.070	0.090	0.025	0.035	0.080	0.095	0.005

Table 40.2
Minimum long-time insulation resistance of Type XHHW, XHH, and RHH wires in megohms based on a conductor kilometer at 97.0°C (206.6°F)

Table 40.2 revised July 13, 2000

AWG size of conductor	Type XHHW and XHH wires with insulation as indicated in Table 15.3	600-V Type RHH wire with insulation as indicated in Table 15.4				2000-V Type RHH wire with insulation as indicated in Table 15.5			
		Wire with insulation consisting of:				Wire with insulation consisting of:			
		Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation	Class CP, CPE, or SBR/ IIR/NR	Class EP, EPCV, or XL	A layer of CP, CPE, EPCV, or XL over a layer of EP	Type RHH wire with silicone rubber insulation
14	0.060	0.030	0.075	0.075	0.015	0.045	0.090	0.090	0.035
13	0.055	0.030	0.070	0.070	0.105	0.040	0.085	0.085	0.030
12	0.050	0.025	0.065	0.065	0.100	0.040	0.080	0.080	0.030
11	0.045	0.025	0.060	0.060	0.090	0.035	0.075	0.075	0.025
10	0.040	0.025	0.055	0.055	0.085	0.035	0.070	0.070	0.025
9	0.050	0.025	0.065	0.065	0.085	0.030	0.070	0.070	0.025
8	0.045	0.020	0.055	0.055	0.070	0.025	0.060	0.065	0.020
7	0.040	0.020	0.050	0.050	0.065	0.025	0.055	0.065	0.015
6	0.035	0.020	0.045	0.055	0.060	0.025	0.050	0.055	0.015
5	0.035	0.015	0.040	0.050	0.055	0.025	0.045	0.055	0.015
4	0.030	0.015	0.035	0.045	0.050	0.020	0.040	0.050	0.015
3	0.025	0.015	0.035	0.040	0.045	0.020	0.040	0.045	0.010
2	0.025	0.015	0.030	0.035	0.040	0.020	0.035	0.040	0.010
1	0.025	0.015	0.035	0.040	0.045	0.020	0.040	0.045	0.010
1/0	0.025	0.015	0.030	0.040	0.040	0.020	0.035	0.040	0.010
2/0	0.020	0.015	0.030	0.035	0.035	0.015	0.030	0.040	0.010
3/0	0.020	0.010	0.025	0.030	0.035	0.015	0.030	0.035	0.010
4/0	0.020	0.010	0.025	0.030	0.030	0.015	0.025	0.030	0.005

40.1.2 The values in Tables 40.1 and 40.2 apply only to Type XHHW and XHH wires and to 600-V and 2000-V Type RHH wires with insulations of the materials and in the thicknesses that are indicated in Tables 15.3 (Type XHHW and XHH), 15.4 (600-V Type RHH), and 15.5 (2000-V Type RHH). For other thicknesses of the same materials and for other material in any thickness, the insulation resistance values are to be calculated by means of whichever of the following formulas is applicable

$$IR_{97°C} = K_{15.6°C} \times 6.37 \times 10^{-5} \times \log_{10} \frac{D}{d}$$

in which:

No Text on This Page

IR at 97.0°C (206.6°F) is the insulation resistance in megohms based on 1000 conductor feet at 102 percent of the absolute dry-locations rated temperature of the wire,

K is the constant for the insulation material at 60.0°F (15.6°C) in megohms based on 1000 conductor feet, 6.37 x 10^{-5} is the multiplier for reducing K at 60.0°F (15.6°C) to the value it would have at 97.0°C (206.6°F),

D is the diameter over the insulation in inches, and

d is the diameter of the metal conductor in inches; or

$$IR_{97°C} = K_{15.6°C} \times 1.94 \times 10^{-5} \times \log_{10} \frac{D}{d}$$

in which:

IR at 97.0°C (206.6°F) is the insulation resistance in megohms based on a conductor kilometer at 102 percent of the absolute dry-locations rated temperature of the wire,

K is the constant for the insulation material at 60.0°F (15.6°C) in megohms based on 1000 conductor feet, 1.94 x 10^{-5} is the multiplier for reducing K at 60.0°F (15.6°C) in megohms based on 1000 conductor feet to the value it would have at 97.0°C (206.6°F) in megohms based on a conductor kilometer,

D is the diameter over the insulation in millimeters, and

d is the diameter of the metal conductor in millimeters.

40.2 Maximum rate of decrease

40.2.1 The insulation indicated in 40.1.1 shall also have the effect that, during the extended period in the oven of Type XHHW, XHH, and RHH wires at 97.0 ±1.0°C (206.6 ±1.8°F), the maximum decrease in insulation resistance per week, as determined from a curve (drawn to represent the average of actual values), for every continuous period of 3 weeks during the latter half of the specified period of time in the oven is not more than 4 percent when the insulation resistance on the basis of 1000 conductor feet is 10 megohms or more (3 megohms or more based on conductor kilometer); and is not more than 2 percent when the insulation resistance is less than 10 and more than the value indicated in Table 40.1 (less than 3 megohms and more than the value indicated in Table 40.2).

40.3 Test method

40.3.1 The test to determine whether or not the insulation complies with the requirements in 40.1.1 and 40.2.1 is to be made on three or more 50-ft or 20-m coils of finished, unaged wire with a snug-fitting close-weave outer braid of copper applied over the insulation. Except for the use of a large full-draft circulating-air oven complying with 420.9 of UL 1581with provision for bringing out the necessary wire leads, and except that a tank and water are not involved because this is a dry test in heated air, the test

is to be made with the equipment and according to the method described in Insulation-Resistance Test in Water, Section 920 of UL 1581. Before the test voltage is applied, the copper braid is to be removed from each end of each coil for a distance of 6 – 8 inches or 150 – 200 mm.

40.3.1 revised March 22, 1999

40.3.2 For a coil that shows a greater percent decrease in insulation resistance during the extended period of time in the oven than specified in 40.2.1 shall be tested for additional 1-week periods in the oven and judged on the basis of the results for every continuous period of 3 weeks during the last 12 weeks in the oven. In each such case, the final insulation resistance is not to be less than specified in the applicable Table 40.1 or 40.2.

40.3.2 revised March 22, 1999

ALTERNATIVE SPARK TESTING

41 General

41.1 For the factory production testing of single-conductor 600-V and 2000-V wires, the a-c spark test described in Spark Test Method, Section 900 of UL 1581 is an alternative to the Dielectric Voltage-Withstand test in 36.1– 36.3 and the 60.0°F (15.6°C) Insulation-Resistance Test in 36.1– 38.1. Within a given factory either of the above alternatives is appropriate for any given combination of size and type of wire and once chosen it is to apply to 100 percent of each production run of that combination at that factory. The test potential shall be as indicated in Table 41.1.

41.1 revised March 22, 1999

Table 41.1
Spark-test potential

Table 41.1 revised April 1, 2002

Size of wire	RMS test potential in kilovolts	
	600-V wire	2000-V wire
AWG		
14 – 10	7.5	10.0
9 – 2	10.0	12.5
1 – 4/0	12.5	15.0
kcmil		
213 – 500	15.0	17.5
501 – 1000	17.5	20.0
1001 – 2000	17.5	22.5

CAPACITANCE AND RELATIVE-PERMITTIVITY TESTS

42 General

42.1 The insulation on Type XHHW-2, RHW-2, XHHW, and RHW wires shall have the effect that specimens of the finished wire that are tested as described under Capacitance and Relative Permittivity, Test, Section 1020 of UL 1581, comply with each of the following:

a) The relative permittivity (dielectric constant) determined with 60 Hz current and at an average stress of 80 volts per mil or 3150 volts per millimeter, after immersion of the specimens for 24 h, shall be 10.0 or less for Class CP or CPE insulation and 6.0 or less for all other insulations.

b) The capacitance determined after immersion for 14 d shall, for Class CP and CPE insulation, not be more than 6.0 percent higher than the capacitance measured after the 24-h immersion and, for all other insulations, shall not be more than 10.0 percent higher than the capacitance measured after the 24-h immersion.

c) The capacitance determined after immersion for 14 d shall, for Class CP and CPE insulation, not be more than 2.0 percent higher than the capacitance measured after immersion for 7 d and, for all other insulations, shall not be more than 4.0 percent higher than the capacitance measured after immersion for 7 d.

42.1 revised March 22, 1999

TEST FOR STABILITY FACTOR

43 General

43.1 The insulation shall have the effect that specimens of the finished wire that are immersed continuously in tap water for 14 d at a temperature of 75.0 ±1.0°C (167.0 ±1.8°F) for Types XHHW and RHW, or at 90 ±1°C (194 ±1.8°F) for Types XHHW-2 and RHW-2 comply with one of the following requirements when tested as described under Stability Factor Test, Section 1000 of UL 1581:

a) The stability factor (the numerical difference between the percentage power factors measured with 60 Hz current at average stresses of 80 and 40 volts per mil or 3150 and 1575 volts per millimeter) determined after the fourteenth day of immersion shall be 1.0 or less, or

b) The stability factor determined after the first day subtracted from the stability factor determined after the fourteenth day shall be 0.5 or less.

TEST FOR GLASS CONTENT OF BRAID ON TYPE SA WIRE

44 General

44.1 An all-glass braid on Type SA wire, after removal of the saturant, shall contain glass in the amount of 70 percent or more by weight when tested as indicated in Asbestos, Glass, or Asbestos-and-Glass Content, Test, Section 1250 of UL 1581.

TEST FOR FALLING PARTICLES AND DRIPPING FROM FIBROUS-COVERED WIRE AND CABLE

45 General

45.1 The saturant (see 26.1 and 26.2), the finish (see 27.1), and any lubricant (see 29.1) used in and/or on a fibrous-covered wire or cable shall not soften to the point of dripping from a specimen of the finished wire or cable, nor shall the constituents of the saturating, finishing, and lubricating compounds be volatile to the point of evaporating to the degree that particles fall from a specimen of the finished wire or cable while a specimen is being heated as indicated in Falling Particles and Dripping from Fibrous-Covered Wire and Cable, Test, Section 1630 of UL 1581.

TEST FOR MOISTURE ABSORPTION BY FIBROUS COVERINGS OTHER THAN TAPE

46 General

46.1 A fibrous covering other than a tape shall not absorb more moisture than 20 percent of its weight while immersed in tap water at 21.0 ±1.0°C (69.8 ±1.8°F) for 24 h. In the case of an assembly for use in armored cable, any fibrous covering on the individual wires is to be tested separately from and also simultaneously with an overall fibrous covering on the assembly. The test is to be conducted as described in Moisture Absorption by Fibrous Coverings Other than Tape, Test, Section of 1610 of UL 1581.

COLD-BEND TEST

47 General

47.1 There shall not be any crack(s) in the insulation and there shall not be any crack(s) in the jacket or any break(s) in any binder thread or threads of a fibrous covering of any insulated wire, cable, or assembly when a sample of the finished wire, cable, or assembly is bent in the manner described in 1610.3 of UL 1581 (except that adjacent turns are to touch one another) around a mandrel of the diameter specified in Table 1610.1 of UL 1581 (single conductor) or in Table 1610.2 of UL 1581 (multiple-conductor cable or assembly). The wire, cable, or assembly and the mandrel are to be cooled for 4 h to a temperature of -25.0 ±2.0°C (-13.0 ±3.6°F) and are to be at that temperature during the bending.

47.1 revised March 22, 1999

COLD-IMPACT TEST

48 General

48.1 A wire or cable is resistant to a temperature of -40°C (-40°F) if the finished wire or cable shows no cracking of the insulation, no cracking of any jacket, and no broken thread or threads of any fibrous covering when a specimen of the finished wire or cable is cooled for at least 4 h in air maintained at a low temperature of -40.0 ±2.0°C (-40.0 ±3.6°F) for 4 h and is then subjected to the energy of a free-falling, flat-faced, 3-lb or 1.36-kg weight, that is 1 inch or 25 mm in diameter and falls through a distance of 36 inches or 915 mm and impacts the specimen laid on a wooden anvil. The test is to be conducted as described in Impact at Abnormally Low Temperature, Test, Section 593 of UL 1581. The marking ″-40C″ or ″minus 40C″ is required on the surface (see 60.23) and on the tag, reel, or carton (see 60.34(i)).

48.1 revised March 22, 1999

DEFORMATION TEST

49 General

49.1 Specimens of Class XL insulation from finished wire and cable shall not decrease more than 30 percent (14 – 4/0 AWG) or 15 percent (213 – 2000 kcmil) in thickness under the load indicated in Table 49.1 while being maintained at a temperature of 121.0 ±1.0°C (249.8 ±1.8°F) for 60 min. The test is to be conducted as described in Deformation, Test, Section 560 of UL 1581.

49.1 revised April 1, 2002

Table 49.1
Specimen loading

Table 49.1 revised March 22, 1999

Size of specimen	Minimum load[a] exerted on a specimen by the foot of the rod	
	gf	N
AWG		
14 – 7	500	4.90
6 – 1	750	7.35
1/0 – 4/0	1000	9.81
kcmil		
213 – 2000 (planed or buffed specimens)	2000	19.61

[a]The specified load is not the weight to be added to each rod in the test apparatus. It is the total of the weight added and the weight of the rod. Because the weight of the rod varies from one apparatus 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.

CRUSHING TEST (TYPES XHHW-2, XHHW, AND XHH)

50 General

50.1 An average of at least 1200 lbf or 5338 N or 544 kgf shall be necessary to crush finished solid No. 14 AWG Type XHHW-2, XHHW, and XHH wires to the point that the conductor contacts the earth-grounded metal of the testing machine. An average of at least 1800 lbf or 8007 N or 816 kgf shall be required to crush finished stranded No. 2 AWG Type XHHW-2, XHHW, and XHH wires to the point that the conductor contacts the earth-grounded metal of the testing machine. The test is to be conducted as described in Crushing-Resistance Test of Types XHHW and XHH, Section 620 of UL 1581.

50.2 The results of this test on the 14 and 2 AWG sizes shall represent the performance of all 14 AWG – 2000 kcmil Type XHHW-2, XHHW, and XHH wires with the same insulation compound.

50.2 revised April 1, 2002

TEST FOR DIELECTRIC BREAKDOWN AFTER GLANCING IMPACT (TYPES XHHW-2, XHHW, AND XHH)

51 General

51.1 The average breakdown potential of finished solid 14 AWG Type XHHW-2, XHHW, and XHH wires that have separately been subjected to a glancing impact of 18 in-lbf or 2 J or 0.207 m-kgf shall not be less than 20 percent of the average breakdown potential of the same wire not subjected to the impact. The test is to be conducted as described in Dielectric Breakdown Test of Types XHHW-2, XHHW, and XHH after Glancing Impact, Section 700 of UL 1581.

51.1 revised April 1, 2002

TEST FOR DIELECTRIC BREAKDOWN AFTER SCORING (TYPES XHHW-2, XHHW, AND XHH)

52 General

52.1 The average breakdown potential of finished solid 14 AWG Type XHHW-2, XHHW, and XHH wires that have separately been scored shall not be less than 25 percent of the average breakdown potential of the same, unscored wire. The test is to be conducted as described in Dielectric Breakdown Test of Types XHHW-2, XHHW, and XHH after Scoring, Section 720 of UL 1581.

52.1 revised April 1, 2002

HORIZONTAL-SPECIMEN FLAME TEST

53 General

53.1 A finished single-conductor wire or cable of any construction, a finished fibrous-covered or jacketed insulated conductor for use in armored cable, a finished fibrous-covered multiple-conductor cable (cable that qualifies for the suffix letter ″D″ or ″M″ indicated in 60.40), and a finished fibrous-covered multiple-conductor assembly, including any fillers, for use in armored cable shall be capable of complying with the Horizontal-Specimen Flame Test, Section 1100 of UL 1581.

Revised 53.1 effective December 19, 1999

53.2 Deleted effective December 19, 1999

VW-1 (VERTICAL-SPECIMEN) FLAME TEST

54 General

54.1 For a given size of a finished wire or cable to be marked VW-1, that size and the 14 AWG size for wire with copper conductor or that size and the 12 AWG size for wire with an aluminum conductor of that construction shall be capable of complying with the horizontal flame test referenced in 53.1 and shall also be capable of complying with the VW-1 (Vertical-Specimen) Flame Test, Section 1080 of UL 1581. A finished wire or cable with a color overcoating or other extra overall coating is to be horizontal flame tested and VW-1 flame tested both with and without the coating. See marking in 60.22.

Revised 54.1 effective December 19, 1999

54.2 Deleted effective December 19, 1999

VERTICAL-TRAY FLAME TEST

55 General

55.1 4 – 1 AWG Type XHHW-2, XHHW, XHH, RHW-2, RHW, RHH, and SA finished single insulated equipment-grounding conductors that are colored green in accordance with 60.27 and all 1/0 AWG and larger finished single circuit and grounding conductors of the same types, are eligible to be marked (see 60.16 and 60.17) to indicate use in cable trays when the insulation does not exhibit cable damage that reaches the limit for any specimen after two sets of specimens of the specific wire or cable type are tested in accordance with the UL Flame Exposure, Sectiions 4 – 11 of Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables of UL 1685, or the FT4/IEEE 1202 Type of Flame Exposure, Sections 12 – 19 of UL 1685. Smoke measurements are not applicable. Types RHW-2, RHW, and RHH are to be tested separately unless the two type-letter designations are marked on a single cable as indicated in 60.13.

55.1 revised April 1, 2002

55.2 All sizes of finished multiple-conductor Type XHHW-2, RHW-2, XHHW, XHH, RHW, RHH, and SA cables (these cables carry the suffix letters D and M as indicated in 60.40) that are to be marked (see 60.16 – 60.18) for use in cable trays are eligible to be marked for use in cable trays when two sets of specimens of the 9-conductor No. 12 AWG construction are tested to and comply with the requirements of either the UL Flame Exposure test, Sections 4 – 11 of Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685 or the FT4/IEEE 1202 Type of

Flame Exposure test, Sections 12 – 19 of UL 1685. Smoke measurements are not applicable. Each multiple-conductor type is to be tested separately unless multiple type-letter designations are marked on a single cable as indicated in 60.13.

55.2 revised July 13, 2000

55.3 The results of the test using 1/0 AWG single conductors are representative of the performance of the specific wire Type for all 1/0 AWG and larger sizes. The results of the test using 4 AWG single conductors are representative of performance of the specific wire Type for all 4 AWG and larger size insulated equipment-grounding conductors and all 1/0 AWG and larger circuit and grounding conductors.

55.3 revised April 1, 2002

55.4 The results of the test using 9-conductor 12 AWG specimens shall be representative of the performance of the finished multiple-conductor Type XHHWD, XHHWM, XHHD, XHHM, RHD, RHM, RHWD, RHWM, RHHD, RHHM, SAD, and SAM cables in all of the sizes 14 AWG – 2000 kcmil. No multiple-conductor construction of the cable is eligible to be marked for use in cable trays when any of the specimens tested exhibits damage that does not comply with the requirements of the test.

55.4 revised April 1, 2002

SUNLIGHT-RESISTANCE TEST

56 General

56.1 A wire or cable marked for the sunlight-resistance application indicated in 60.16 or 60.18 (tray use) or 60.19 (messenger use) shall comply with the Carbon-Arc and Xenon-Arc Tests, Section 1200 of UL 1581, using 720 h of either carbon-arc exposure or xenon-arc exposure. Each single-conductor type is to be tested separately unless multiple type- letter designations are marked on a single cable as indicated in 60.13.

56.1 revised March 22, 1999

56.2 All sizes of finished multiple-conductor Type XHHW-2, RHW-2, XHHW, XHH, RHW, and RHH cables (these cables carry the suffix letters D and M as indicated in 60.40) that are jacketed are eligible to be marked (see 60.16) for sunlight-resistant use in cable trays when the overall jacket from the finished 9-conductor 12 AWG construction complies with the Carbon-Arc and Xenon-Arc Tests, Section 1200 of UL 1581, using 720 h of either carbon-arc exposure or xenon-arc exposure. Each multiple-conductor type is to be tested separately unless multiple type-letter designations are marked on a single cable as indicated in 60.13.

56.2 revised April 1, 2002

56.3 The results of the test using 1/0 AWG single-conductor specimens shall be representative of the performance of the finished single-conductor cable in any of the sizes 1/0 AWG – 2000 kcmil.

56.3 revised April 1, 2002

56.4 The results of the test using specimens of the overall jacket from 9-conductor 12 AWG cable shall be representative of the performance of the finished multiple-conductor jacketed Type XHHW-2D and XHHW-2M, XHHWD and XHHWM, XHHD and XHHM, RHW-2D and RHW-2M, RHD and RHM, RHWD and RHWM, or RHHD and RHHM cable in any of the sizes 14 AWG – 2000 kcmil containing two or more conductors.

56.4 revised April 1, 2002

LIMITED SMOKE

57 General

Section 57 added March 22, 1999

57.1 Multiple-conductor and single-conductor wires and cables of Type XHHW-2, RHW-2, XHHW, XHH, RHW, RHH, and SA are eligible to be marked (see 60.20) to indicate limited smoke (-LS) after sets of specimens as described in 57.2 are tested in accordance with the Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685, and comply with the smoke release and cable damage requirements therein.

57.1 revised July 13, 2000

57.2 Specimens for Flame-Propagation and Smoke-Release (-LS) testing shall consist of the smallest, largest, and an intermediate size of each construction indicated in 57.1 plus any other size(s) in each construction that is appropriate because of the cable geometry and/or materials. Only finished cable is to be tested.

TESTS FOR OIL-RESISTANCE

58 General

58.1 A wire or cable is oil-resistant at 75°C (167°F) when the retention of the tensile strength and ultimate elongation of the insulation is not less than 65 percent when tubular or die-cut specimens (as applicable) are tested after immersion of the finished wire or cable in oil for 60 d at a temperature of 75.0 ±1.0°C (167.0 ±1.8°F) as described in 480.6 of UL 1581.

58.2 A wire or cable is oil-resistant at 60°C (140°F) when the retention of tensile strength and ultimate elongation of the insulation is not less than 50 percent when tabular or die-cut specimens (as applicable) are tested after immersion of the finished wire or cable in oil for 96 h at 100.0 ±1.0°C (212.0±1.8°F) as described in 480.6 of UL 1581.

TESTS FOR GASOLINE- AND OIL-RESISTANCE

59 General

59.1 A 14 AWG – 1000 kcmil thermoset-insulated wire or cable is gasoline-resistant and oil-resistant when:

a) The retention of tensile strength and ultimate elongation of the insulation is not less than 75 percent when tubular specimens or, where there is adequate material for die-cut specimens are tested after immersion of the finished wire or cable in water-saturated ASTM Reference Fuel C (see 480.11 of UL 1581 and ASTM D 471-98) for 30 d at 23.0 ±1.0°C (73.4 ±1.8°F) as indicated in 480.10 of UL 1581, and

b) The wire complies with the requirements for oil-resistance in 58.1 or 58.2. This test is to be performed on specimens in each of the sizes 14 AWG – 1000 kcmil.

59.1 revised April 1, 2002

MARKINGS

60 Details

60.1 All printing on the outer surface of a wire or cable or anywhere within a wire or cable shall be repeated at the following intervals throughout the length of the wire or cable:

a) Markings on the outer surface of the wire or cable:

1) Size shall be repeated at intervals that are not longer than a nominal 24 inches or 610 mm (maximum 25 inches or 635 mm).

2) The marking in 60.37 for identification of copper-clad aluminum shall be repeated at intervals that are not longer than 6 inches or 150 mm.

3) All information other than size and the identification of copper-clad aluminum shall be repeated at intervals that are not longer than 40 inches or 1.02 m.

b) Size and all other information on a marker tape shall be repeated at intervals that are not longer than a nominal 24 inches or 610 mm (maximum 25 inches or 635 mm).

60.2 Except as noted in 60.9, a wire or cable shall have a permanent distinctive marking throughout its entire length to readily identify the wire or cable as the product of the organization that is responsible for the wire or cable. Additional information shall not confuse or mislead.

a) In the case of a jacketed wire or cable or a wire or cable not having a covering over the insulation, the marking shall be readily legible on the outer surface of the jacket or insulation and shall consist of ink printing (see test in 60.4), indent printing (see 60.8), or embossing of the information indicated in 60.5.

b) In the case of a fibrous-covered wire or cable and as a supplement to ink printing of wire or cable [see (a) above] that is not tested or does not conform to 60.4, the marking shall be located in the outermost fibrous covering or anywhere within the wire or cable and shall consist of a thread or threads whose color or combination of colors is assigned (see 60.10 and 60.33), a tape legibly printed with the information indicated in 60.5 (not an option under the insulation), or indent stamping of the conductor metal that does not embrittle the metal.

60.2 revised March 22, 1999

60.3 When the organization responsible for the wire or cable produces the wires or cables covered in this Standard in more than one factory, the marking in 60.2 shall include an identification of the factory. In the case of a colored thread or threads, the ply or the material of one or more of the threads used at each factory shall be different from the ply or material of the same color thread or threads used at every other factory. The organization responsible for the wire or cable shall make available the meaning of the different plies and materials.

60.4 Printing of the responsible organization and factory identification on the outer surface is to remain legible after specimens are rubbed repeatedly with a felt-faced weight as described in Durability of Indelible-Ink Printing, Test, Section 1690 of UL 1581.

60.4 revised March 22, 1999

60.5 The identification of the organization responsible for the wire or cable required in 60.2 and provided by means of ink or indent printing, embossing, or a printed tape shall consist of the name of the wire or cable manufacturer, that manufacturer's trade name for the wire or cable, or both, or any other appropriate distinctive marking by means of which the organization responsible for the wire or cable is readily identifiable. When the organization that is responsible for the wire or cable is different from the actual manufacturer, both the responsible organization and the actual manufacturer shall be identified by name or by appropriate coding such as by trade name, trademark, the assigned electrical reference number, or the assigned combination of colored marker threads. The meaning of any coded identification shall be made available. It is appropriate to also identify a private labeler; the means is not specified..

60.6 The outer surface of the overall covering on a pump cable of any of the constructions detailed in 35.1 (a), (c) and (d) shall be durably and legibly marked ″submersible pump cable″. When each circuit conductor is not surface-marked with its type-letter designation, the marking on the outer surface of the pump cable shall include the conductor type letters.

60.7 Each wire in a cable intended to be used as cable for deep-well submersible water pumps is eligible to be durably and legibly marked ″pump cable″ on its surface. In a pump cable without an overall covering, the surface of each circuit conductor shall be durably and legibly marked with the conductor type letters.

60.8 Indent printing and embossing shall not reduce the thickness of the jacket or insulation below the indicated minimum at any point.

60.9 The marking identifying the responsible organization and factory in the case of a wire that is intended for further processing (wire intended to become a component of a cable in another category) is not required when both the wire and the finished cable are produced in the same factory.

60.10 When a glass-fiber thread or threads are employed as the identifying marker, the length of lay of the filaments in each basic strand shall not be longer than 1/3 inch or 8.5 mm.

60.11 A wire or cable shall have a readily identifiable durable outside marking, or a printed tape marker in a multiple-conductor or metal-sheathed cable, to indicate the type-letter designation for the wire or cable. Inclusion of the word ″Type″ is not required.

60.12 A wire shall have the conductor size legibly marked on its outer surface in durable printing, except that this marking is not required on wire intended for further processing, or for use in a multiple-conductor wire or cable. In the case of a multiple-conductor wire or cable, the outer covering shall bear this marking. The nominal metric cross-sectional area in square millimeters as shown in UL 1581, Table 20.1, when added shall be indicated before or after the required size designation, with either the required or metric size in parentheses– for example, ″8 AWG (8.367 mm^2)″ or ″8.367 mm^2(8 AWG)″. The abbreviation ″sq mm″ or ″SQ MM″ or ″MM2″ is to be used when replacing ″mm^2″. The metric size when used is to be rounded off in accordance with ASTM E 29-93a(R1999) to at least three significant figures.

60.12 revised April 1, 2002

60.13 It is appropriate to mark ″RHH or RHW″ on a single-conductor wire or cable that complies with all of the requirements for single-conductor Type RHH wire and with all of the requirements for single-conductor Type RHW wire. It is appropriate to mark ″RHHD or RHWD″ on a 2-conductor flat parallel jacketed or fibrous-covered cable that complies with all of the requirements for Type RHHD and with all of the requirements for Type RHWD. It is appropriate to mark ″RHHM OR RHWM″ on a round cable that contains two or more insulated conductors that are cabled under an overall jacket or fibrous covering and that complies with all of the requirements for Type RHHM and with all of the requirements for Type RHWM.

60.14 Wires that are oil-resistant at 60°C (140°F) in accordance with the requirements in 58.2 are eligible to be durably surface-marked ″oil resistant I″. Wires that are oil-resistant at 75°C (167°F) in accordance with 58.1 are eligible to be durably surface-marked ″oil resistant II″.

60.15 Wires that are gasoline-resistant and oil-resistant in accordance with 59.1are eligible to be durably surface-marked ″gasoline and oil-resistant I″ where they are oil-resistant at 60°C (140°F), and ″gasoline and oil-resistant II″ where they are oil-resistant at 75°C (167°F).

60.16 The following cables are eligible to be marked on the outer surface with the designation ″sunlight-resistant, for CT use″ or ″sunlight-resistant, for use in cable trays″ when they comply with the flame-test requirements in 55.1 – 55.4 and with the sunlight-resistance requirements in 56.1 – 56.4. These cables are eligible for the additional designation ″FT4/IEEE 1202″ or ″FT4″ where they comply with the FT4/IEEE 1202 test referenced in 55.1 and 55.2.

a) 4 – 1 AWG Type XHHW-2, XHHW, XHH, RHW-2, RHW, RHH, and SA finished single insulated equipment-grounding conductors that are colored green in accordance with 60.26 and all finished single circuit and grounding conductors 1/0 AWG – 2000 kcmil Type XHHW-2, XHHW, XHH, and SA cables and 1/0 AWG – 2000 kcmil Type RHW-2, RHW and RHH cables that are jacketed or are appropriate for use without any overall covering, and

b) Finished multiple-conductor jacketed Type XHHW-2D and XHHW-2M or XHHWD and XHHWM or XHHD and XHHM or RHW-2D and RHW-2M or RHD and RHM or RHWD and RHWM or RHHD and RHHM or SAD and SAM cable in any size.

60.16 revised April 1, 2002 |

60.17 The following cables are eligible to be marked on the outer surface with the designation ″for CT use″ or ″for use in cable trays″ when they comply with the flame-test requirements in 55.1– 55.4 and have not been tested for sunlight-resistance or do not comply or do not comply with the sunlight-resistance requirements in 56.1 – 56.4. These cables are eligible for the additional designation ″FT4/IEEE 1202″ or ″FT4″ where they comply with the FT4/IEEE 1202 test referenced in 55.1 or 55.2.

a) 4 – 1 AWG Type XHHW-2, XHHW, XHH, RHW-2, RHW, RHH, and SA finished single insulated equipment-grounding conductors that are colored green in accordance with 60.26 and all finished single circuit and grounding conductors. 1/0 AWG – 2000 kcmil of the same types and

b) Finished multiple-conductor jacketed or fibrous-covered Type XHHW-2D and XHHW-2M or XHHWD and XHHWM or XHHD and XHHM or RHW-2D and RHW-2M or RHD and RHM or RHWD and RHWM or RHHD and RHHM or SAD and SAM cable in any size.

60.17 revised April 1, 2002 |

60.18 Single-and multiple-conductor wires and cables that are of a construction other than mentioned in 60.16 and 60.17 are not for use in cable trays and so shall not be marked as indicated in 60.16 and 60.17.

60.18 revised March 22, 1999

60.19 Any size of single-conductor or jacketed multiple-conductor Type XHHW-2, XHHW, RHW-2, or RHW wire that complies with the sunlight- resistance requirements in 56.1 and is intended for use as messenger-supported wiring that is exposed to the weather is eligible to be marked on its outer surface with the designation ″sun-res″ or ″sunlight-resistant″.

60.20 Multiple-conductor and single-conductor wires and cables of Type XHHW-2, RHW-2, XHHW, XHH, RHW, RHH, and SA that comply with the flame-propagation and smoke-release requirements indicated in 57.1 and 57.2 are eligible to be marked on the outer surface with the designation ″-LS″. Where used, the ″-LS″ designation shall be added as a suffix immediately following the type letters.

60.20 added July 13, 2000

60.21 The outer surface of a wire or cable, or a printed tape in the case of a metal-sheathed cable, shall be durably and legibly marked with ″600 volts″, ″600 V″, ″2000 volts″, or ″2000 V″ or ″2 kV″ as applicable to indicate the voltage rating of the wire or cable.

60.22 Wires and cables that comply with the VW-1 requirements in accordance with 54.1 are eligible to be marked ″VW-1″.

60.22 revised March 22, 1999

60.23 A wire or cable that complies with 48.1 (cold impact test) shall be surface marked ″-40C″ or ″minus 40C″. This marking is also required on the tag, reel, or carton – see 60.34(i).

60.24 AUTHORIZED SURFACE MARKING – An authorized Canadian Standards Association (CSA) type designation that includes numbers indicative of a temperature rating is eligible to be surface marked on a wire or cable in addition to the markings required in this Standard. The CSA designation shall be clearly associated with CSA and clearly separated by ″or″, a dash, or a wide space from the legend required in this Standard.

60.25 TAG, REEL, OR CARTON MARKINGS NOT TO BE USED – Any designation that is other than as described in 60.24 and is not completely indicative of the meaning of the National Electrical Code type letters for a wire or cable shall not be marked in words on or in the wire or cable or on any tag, reel, or carton for the wire or cable. For example, the temperature rating ″75 C″, the current rating ″40 amps″, and the wording ″heat resistant″ are precluded from a 10 AWG copper Type RHW wire because, although they are suggestive of the meaning of the H in the type letters, these designations taken alone or together do not account for the type of circuit, the number of conductors, the ambient temperature, and other influences whose consideration is required for determining the correct maximum current for the wire in a particular installation. Such determination can be made only by using the factors found for the wire type in the National Electrical Code.

60.25 revised April 1, 2002

60.26 AUTHORIZED TEMPERATURE THREAD AND TAG, REEL, OR CARTON MARKING – A temperature marker thread is appropriate for use in a wire or cable of a National Electrical Code type that is additionally authorized for use(s) not covered by the National Electrical Code. Where the non-NEC temperature rating(s) is used in the tag, carton, or reel marking, the marking shall clearly:

a) Tie the rating to the specific non-NEC use to which it applies, and

b) Separates the rating from any NEC type.

For example, a marking such as ″NEC Type__ __C AWM CSA Type__ __C″ is not to be used. ″NEC Type__For use as appliance-wiring material rated__C. CSA Type__rated__C.″ is to be used.

60.26 revised March 22, 1999

60.27 An insulated conductor intended for use as an equipment-grounding conductor shall be finished to show the color green throughout the entire length and circumference of its outer surface with or without one or more straight or helical, broken (non-continuous) or unbroken yellow stripes. See 60.29A for details on stripes. Where there is more than one grounding conductor in an assembly, each must be

distinguishable from the other(s) such as, one striped and one not striped. In the case of a flat cable (see 35.1) that includes an insulated equipment-grounding conductor, the grounding conductor shall be identified as such either as indicated above in this paragraph or by means of readily legible, durable ink printing of ″grounding only″ or an equivalent wording on the outer surface of the finished conductor.

60.27 revised July 13, 2000

60.28 An insulated conductor intended for use as a grounded circuit conductor shall be finished to show the color white or grey throughout the entire length and circumference of its outer surface, or shall be identified by three continuous straight or helical, unbroken white stripes on other than green insulation, along its entire length. Straight stripes are to be placed a nominal 120° apart. Where multiple grounded circuit conductors are used in a cable, no more than one shall employ white stripes. A white or grey conductor intended for use where different systems are installed in the same raceway, box, gutter, or other wiring enclosure also complies with the intent of this requirement where it has a raised tracer or one or more broken (non-continuous) or unbroken straight or helical stripes that are of a contrasting color other than green or green and yellow. See 60.29A for details on stripes.

60.28 revised April 1, 2002

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

a) One or more broken or unbroken straight or helical stripes.

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

c) Numerals, letters, and/or words that comply with this standard.

See 60.29A for details on stripe dimensions.

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

60.29 revised April 1, 2002

60.29A Stripes as specified in 60.27 – 60.29 shall be of even or varying width and shall occupy a total of 5 – 70 percent of the calculated circumference of the outer surface of the finished insulated conductor with no individual width less than 5 percent of that same circumference. The width shall be measured perpendicular to each stripe. Where broken stripes are appropriate, they shall consist of a series of identical marks and spaces, the length of each mark shall be at least 1/8 inch or 3 mm and the linear spacing between marks shall not be greater than 3/4 inch or 19mm.

60.29A added July 13, 2000

60.30 Deleted July 13, 2000.

60.31 Deleted July 13, 2000.

60.32 Deleted July 13, 2000.

60.33 Tracer threads in the fibrous covering are eligible for use as the responsible organization's identifying marker required in 60.2. A conductor finished to show a solid color other than white or natural grey shall not have any white or natural grey as a stripe or tracer marking or otherwise.

60.34 A tag on which the following information is indicated plainly (the sequence of the items is not specified) shall be tied to every shipping length of finished wire or cable. However, where the wire or cable is wound on a reel or coiled in a carton, it is appropriate for the tag to be glued, tied, stapled, or otherwise attached to the reel or carton instead of to the wire or cable, or for the tag to be eliminated and the information printed or stenciled directly onto the reel or carton. Other information, where added, shall not confuse or mislead and shall not conflict with these requirements. See 60.43 for date marking.

a) The maximum voltage for which the wire or cable is rated:

″600 volts″ or ″600 V″ or ″2 kV″ or ″2000 V″ or ″2000 volts″.

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

c) Deleted

d) The AWG or kcmil size of the wire or cable. The nominal metric cross-sectional area, where added, shall be as described in 60.12.

e) The type-letter designation for the wire or cable.

f) The colored-thread marker assigned to identify the organization responsible for the wire or cable where the threads are used in the wire or cable.

g) For submersible-water-pump cable, the following wording(s) or other wording(s) to the same effect:

″For use within the well casing for wiring deep-well water pumps where the cable is not subject to repetitive handling caused by frequent servicing of the pump units.″

In addition where applicable (see 14.1):

″CAUTION – Insulation may adhere tightly to the conductor. Take care to remove all insulation before terminating the conductor.″

h) For Types RHW and RHH with CP, CPE, EPCV, or XL over EP insulation and rated for 600 V (see Table 15.4 for thickness) or for 2000 V (see Table 15.5 for thickness):

"Maximum number of conductors in conduit or tubing must be calculated using the methods described in Chapter 9 of the National Electrical Code or, for the 600-V rating, may be taken from the table for RHW, RHH (with outer covering) also in Chapter 9 of the National Electrical Code."

i) For a wire or cable that complies with 48.1 (cold impact test): "-40C" or "minus 40C".

60.34 revised April 1, 2002

60.35 In addition to the markings required in 60.34, a coil or reel or carton of wire or cable that does not have an enclosing or individual fibrous covering or paper wrap and is intended for further processing shall be tagged or marked to indicate the name of the manufacturer or private labeler to whom it is to be shipped.

60.36 When the conductor of a wire or cable is of aluminum, the AWG or kcmil size of the conductor – wherever it appears (on the tag, reel, carton, or on the surface of the wire or cable) – shall be followed by the word "aluminum" or the letters "AL".

60.36 revised April 1, 2002

60.37 The outer surface of the insulation or covering over the insulation on each copper-clad aluminum conductor in a single-conductor wire or cable and in a cable containing two or more conductors shall be durably and legibly ink printed, indent printed, or embossed at intervals not exceeding 6 inches or 150 mm throughout the entire length of the wire or cable with one of the designations "AL (CU-CLAD)", "ALUMINUM (COPPER-CLAD)", "CU-CLAD AL", or "COPPER-CLAD ALUMINUM".

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

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

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

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

60.38 revised April 1, 2002

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

60.40 The following designations shall be used for all wires and cables covered in this Standard to indicate the type letters of the product:

XHHW – Indicates a single conductor having insulation for use in dry locations at 90°C (194°F) and in wet locations at 75°C (167°C). See 39.1.3.

XHHW-2 – Indicates a single conductor having insulation for use in dry or wet locations at 90°C (194°F). See 39.1.3.

XHH – Indicates a single conductor having insulation for use in dry locations at 90°C (194°F).

RHH – Indicates a single conductor having insulation for use in dry locations at 90°C (194°F).

RHW – Indicates a single conductor having insulation for use in dry or wet locations at 75°C (167°F). See 39.1.3.

RHW-2 – Indicates a single conductor having insulation for use in dry or wet locations at 90°C (194°F). See 39.1.3.

SA – Indicates a single conductor having a glass braid and silicone insulation for general use in dry locations at 90°C (194°F) and for special applications in dry locations at 200°C (392°F).

SIS – Indicates a single conductor having insulation for use in only switchboard wiring in dry locations at 90°C (194°F).

D – Used as a suffix indicates a multiple-conductor wire or cable in which two conductors are laid parallel under an outer covering.

M – Used as a suffix indicates a multiple-conductor wire or cable in which two or more conductors are cabled under an outer covering.

60.40 revised July 13, 2000

60.41 The type letters and suffix letters given in 60.40, when used alone, indicate conductors for use at not more than 600 V. Conductors rated for use at 2000 V shall be indicated by adding ″2000 volts″ or ″2000 V″ or ″2 kV″.

60.41 revised March 22, 1999

60.42 When a wire or cable carries a supplementary marking to indicate a subdesignation (such as a style, class, or catalog number) in addition to the type-letter designation with any applicable suffix letter or voltage rating, the marking shall include the words ″Type″ and ″Style″ or the like – for example, ″Type RHWM 2000 volts – Style RR″.

60.43 When a wire or cable also qualifies completely for use as a cable in a different category (such as single-conductor Type USE service-entrance cable), it is appropriate to use an amplified marking (the word ″or″ shall be included) to indicate the additional category and use – for example, ″RHW or USE″.

60.44 DATE OF MANUFACTURE – The date of manufacture by month and year (or in the sequence month, day, and year) shall be included among the tag, reel, or carton markings described in 60.34, or shall be included among the product markings described in this Standard where legible on the outer surface of the wire or cable. The date shall be shown in plain language, not in code.

60.44 added July 13, 2000

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83(4, 13, 44, 444, 493, 719, 805, 854, 1063, 1072, 1277, 1309, 1424, 1425, 1569, 1651, 1655, 1690, 2250)

1285 Walt Whitman Road
Melville, New York 11747-3081
August 25, 1997

TO: **Electrical Council of Underwriters Laboratories Inc.**
Industry Advisory Conference of UL for Armored Cable and Cords
Industry Advisory Conference of UL for NM and UF Cables
Industry Advisory Group of UL for Marine Shipboard Cable
Technical Advisory Panel of UL for Power Wires and Cables
Technical Advisory Panel of UL for Communications and Power-Limited Wire and Cable
Subscribers to UL's Listing Services for
Thermoplastic-Insulated Wires
Armored Cable
Power Limited Circuit Cable
Rubber-Insulated Wires
Communications Cable
Underground Feeder and Branch Circuit Cable
Nonmetallic-Sheathed Cable
Miscellaneous Wire
Service Entrance Cable
Machine-Tool Wires
Medium-Voltage Cable
Power and Control Tray Cable
Shipboard Cable, Marine
Power Limited Fire-Alarm Cable
Non-Power-Limited Fire-Alarm Cable
Metal-Clad Cable
Optical Fiber Cable
Community Antenna Television Cable
Data-Processing Cable
Instrumentation Tray Cable

SUBJECT: **Optional Surface Marking for Wire Products Complying with the IEC 332-3 Flame Test**

At the request of wire manufacturers, UL has subjected Listed wires and cables to the flame test described in IEC 332-3, which is the International Electrotechnical Commission Technical Report ″Tests on Electric Cables Under Fire Conditions, Part 3: Tests on Bunched Wires or Cables″. The IEC test method and sampling are different from the UL and FT4/IEEE 1202 vertical-tray flame tests. The results of the IEC test are independent of any required UL flame test.

UL Listed wires and cable that individually comply with the IEC test conducted at UL Northbrook may be surface marked ″IEC 332-3″ at the wire manufacturer's option. Procedure authorization is necessary. This marking is to be placed at the end of the surface legend. ″Complies with IEC 332-3 flame test conducted by Underwriters Laboratories Inc.″ or an equivalent tag marking is required. The IEC test is not required for the basic UL Listing of the wire product.

Wires and cables with the IEC marking will be IEC 332-3 tested in periodic Follow-up at UL Northbrook.

Manufacturers needing specific details of the IEC 332-3 test should contact Tom Ebert (Extension 43086) or Rick Wadecki (Extension 42276) at UL's Northbrook IL office (847-272-8800).

Manufacturers interested in obtaining authorization in the Follow-UP Service Procedure for the optional IEC tray flame marking on specific wire products should contact Brett Milau at UL's Melville NY office (516-271-6200 Extension 22592) for communications and power-limited cable types, Austin Wetherell at UL's Melville NY office (516-271-6200 extension 22818) for other wire and cable types, Carl Huang at UL's Santa Clara CA office (408-985-2400 Extension 32810) for wires and cables Listed through UL Santa Clara, or Roger Herb at UL's Camas WA office (360-817-5500 Extension 55657) for wires and cables Listed through UL Camas. Testing is required.

UNDERWRITERS LABORATORIES INC.

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83BUL.W01;WHH;mc

Subjects 44, 62, 83, and 1263

1285 Walt Whitman Road
Melville, New York 11747-3081
October 30, 1997

TO: Subscribers to UL's Listing Service for Irrigation Cable OFFY

SUBJECT: List of Compounds Acceptable for Irrigation-Cable Jackets

This bulletin supersedes the Underwriters Laboratories Inc. bulletin of July 12, 1994 on the same subject.

The following is a list of commercially available thermoplastic polyethylene (PE) compounds that UL has found to comply with the requirements for the environmental exposure tests described in the revised Outline of Proposed Investigation of Irrigation cables issued under Subjects 514 and 1263 as a bulletin dated April 23, 1980. They have all exhibited 80 percent of original tensile strength and elongation after the exposures. These compounds may be used interchangeably, without submittal to UL's Engineering Services, with the PE compounds covered in the Type L Follow-Up Service Procedure for Irrigation Cable. Acceptability in any cable construction necessitates compliance with the applicable performance requirements for that cable.

PVC compounds, included in previous bulletins under this subject, are now covered in the QMTT2 category, Polymeric Materials For Use on Wire and Cable.

Any manufacturer interested in obtaining Listing for Irrigation Cable, or in having a particular jacketing compound investigated for use on Irrigation Cable, should contact the UL engineering office to which the manufacturer normally makes submittals.

UNDERWRITERS LABORATORIES INC.

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SR:WHH

0044BUL.W02;WHH;mc

APPENDIX

PE (POLYETHYLENE) COMPOUNDS FOR USE AS IRRIGATION CABLE JACKETS

Compound Supplier	Compound Designation	Color	Generic Class
BP Chemicals Americas Inc. 620 Fifth Avenue New York, NY 10020 Mr. Colin D. Garside	DFDG 0588 Black 21	Black	PE
E. I. Du Pont De Nemours & Co., Inc. Polymer Products Department, ELD Div. Barley Mill Plaza Kirk Mill Building Wilmington, DE 19898 Electrical Industry Group (302) 999-4849	Alathon 1250	Black	PE
Union Carbide Corp. Old Ridgebury Road Danbury, CT 06817 Mr. Luke C. Du 203-794-3046	DFDB 0588 DFDD 6059 DGDJ 3479	Black	PE PE PE