

UL 83

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Thermoplastic-Insulated Wires and Cables

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Thermoplastic-Insulated Wires and Cables, UL 83

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The revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated July 10, 2001. The bulletin(s) is now obsolete and may be discarded.

The revisions dated November 1, 2001 include a reprinted title page (page1) for this Standard.

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

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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.

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1-3	November 1, 2001
4-5	May 4, 2001
6-7	November 1, 2001
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1

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Thermoplastic-Insulated Wires and Cables

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The Department of Defense (DoD) has adopted UL 83 on February 27, 1984. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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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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 250 – 2000 kcmil sizes of 600-V, single-conductor, thermoplastic-insulated wires and cables for use in accordance with the National Electrical Code. Single conductors for use in armored cable and nonmetallic-sheathed cable, deep-well pump cables, and other multiple-conductor assemblies to which no type-letter designations are assigned are included in these requirements.

1.1 revised November 1, 2001

1.2 These requirements do not cover thermoplastic-insulated flexible cords or fixture wires, which are covered in a separate standard.

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

3 References and Terms

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

3.2 *Deleted September 29, 1998*

CONSTRUCTION

GENERAL

4 Materials

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

5 Index Tables

5.1 A thermoplastic-insulated wire or cable shall be as specified in Table 5.1, 5.2, or 5.3 and shall comply in all respects with the requirements for the construction details and test performance that are applicable.

5.2 Tables 5.1, 5.2, and 5.3 serve 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 should always be made. References in square brackets are to UL 1581.

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Table 5.1
Index to requirements for 60 and 75°C wires^a

Table 5.1 revised September 9, 1999

Type-letter designation	TW	THW	Insulated conductors for Type ACTH cable	THWN
Maximum temperature	60°C (140°F) dry or wet	75°C (167°F) dry or wet	75°C (167°F) dry	75°C (167°F) dry or wet
Conductor size	14 AWG – 2000 kcmil (7.1)		14 – 1 AWG (7.1)	14 AWG – 1000 kcmil (7.1)
Conductor metal	Soft-annealed copper for Nos. 14 and 13 AWG; aluminum, copper-clad aluminum, or soft-annealed copper for other sizes (6.3 and 7.1)			
Conductor dimensions	Diameter and cross-sectional area (8.1 and 8.2)			
Conductor – general	Metal coating (9.1 and 9.2)	Splices (11.1 and 11.2)		Separator (10.1 and 10.2)
Conductor resistance	(12.1)			
Conductor stranding	(13.1 – 13.6)			
Insulation – material ^c	PVC	PVC in one or two layers		PVC ^{b,d}
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)			
Physical properties of insulation ^c	PVC			
Nylon jacket	None			(15.1 and 22.1)
Assemblies that include single-conductor thermoplastic-insulated wires	(24.1)			
Pump Cable	General	(25.1)		
	Thickness of jacket	(22.1)		
	Physical properties of PVC jacket ^c	PVC		
Wrap test	None			(26.1)
Dielectric voltage-withstand	(27.1 and 27.2)			
Insulation resistance (short-time)	(30.1)			
Insulation resistance temperature factor	(30.2)			

Table 5.1 Continued on Next Page

Table 5.1 Continued

Type-letter designation	TW	THW	Insulated conductors for Type ACTH cable	THWN
Insulation resistance in water at rated temperature	(30.1.1 – 31.3.1)			
Insulation resistance in air at 97.0°C (206.6°F)	None			
Insulation Resistance in air at 82.0°C (179.6°F)	None		(33.1.1 – 33.3.2)	None
Alternative spark testing	(34.1)			
Continuity	[pars. 900.13 – 900.17 of UL 1581]			
Relative permittivity	(36.1)		None	(36.1)
Room-temperature flexibility	(37.1)			
Heat shock	(38.1)			
Cold bend	(39.1 and 39.2)			
Deformation	(40.1)			
VW-1 Flame Text	(41.1)			
Horizontal Flame Test	(42.1)			
Vertical Flame Test	(43.1)			
Vertical-Tray Flame Test	(44.1 and 44.2)		None	(44.1 and 44.2)
Tray-Cables Sunlight-Resistance Test	(45.1 and 45.2)		None	(45.1 and 45.2)
Sunlight-Resistance Test for messenger use	(45.1 and 45.2)		Messenger use not applicable	(45.1 and 45.2)
Oil-resistant wires	(46.1 and 46.2)			
Gasoline resistant and oil-resistant wires	None		(47.1)	
Abrasion Test	None			(49.1)
Crushing Test	None			(50.1)
Impact Test	None			(51.1)
Color Coating	(52.1)			
Markings	(53.1 – 72.1)			
^a See 5.2.				
^b Type THWN wire is required to have over the insulation a jacket of nylon whose minimum thickness at any point is as specified in Table 15.5 (see also 14.1).				
^c The physical properties requirements for individual materials are in UL 1581. See 47.1 and index Table 47.1 in UL 1581. See also 40.2 of UL 1581.				
^d Type THWN wire shall employ insulation of PVC or a thermoplastic material other than PVC. See 23.1.				

Table 5.2
Index to requirements for 90°C wires^a

Table 5.2 revised September 9, 1999

Type-letter designation	THW-2	THHW	THWN-2	THHN	Insulated conductors without a nylon jacket for Type ACTHH, NM-B, and NMC-B cables	Insulated conductors without a nylon jacket for Type UF-B cable
Maximum temperature	90°C (194°F) dry or wet	90°C (194°F) dry 75°C (167°F) wet	90°C (194°F) dry or wet	90°C (194°F) dry		90°C (194°F) dry 60°C (140°F) wet
Conductor size	14 AWG – 2000 kcmil (7.1)	14 AWG – 1000 kcmil			14 – 1 AWG (7.1)	14 – 6 AWG (7.1)
Conductor metal	Soft-annealed copper for Nos.14 and 13 AWG; aluminum, copper-clad aluminum, or soft-annealed copper for other sizes (6.3 and 7.1)					
Conductor dimensions	Diameter and cross-sectional area (8.1 and 8.2)					
Conductor – general	Metal coating (9.1 and 9.2)		Splices (11.1 and 11.2)		Separator (10.1 and 10.2)	
Conductor resistance	(12.1)					
Conductor stranding	(13.1 – 13.6)					
Insulation – material ^c	PVC in one or two layers	PVC	PVC ^{b,d}		PVC ^d	PVC
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)					
Physical properties of insulation ^c	PVC					
Nylon jacket	None		(15.1 and 22.1)		None	
Assemblies that include single-conductor thermoplastic-insulated wires	(24.1)					

Table 5.2 Continued on Next Page

Table 5.2 Continued

Type-letter designation		THW-2	THHW	THWN-2	THHN	Insulated conductors without a nylon jacket for Type ACTHH, NM-B, and NMC-B cables	Insulated conductors without a nylon jacket for Type UF-B cable
Pump cable	General	(25.1)			None		
	Thickness of jacket	(22.1)			None		
	Physical properties of PVC jacket ^c	PVC			None		
Wrap Test		None		(26.1)		None	
Dielectric voltage-withstand		(27.1 and 27.2)					
Insulation resistance (short-time)		(30.1)					
Insulation resistance temperature factor		(30.2)					
Insulation resistance in water at rated temperature		(31.1.1 – 31.3.1)			None		(31.1.1 – 31.3.1)
Insulation resistance in air at 97.0°C (206.6°F)		None			(32.1.1 – 32.3.2)		
Insulation resistance in air at 82.0°C (179.6°F)		None	(33.1.1 – 33.3.2)	None			
Alternative spark testing		(34.1)					
Continuity		[900.13 – 900.17 of UL 1581]					
Relative permittivity		(36.1)			None		(36.1)
Room-temperature flexibility		(37.1)					
Heat shock		(38.1)					
Cold bend		(39.1 and 39.2)					
Deformation		(40.1)					
VW-1 Flame Test		(41.1)			None		
Horizontal Flame Test		(42.1)			None		
Vertical Flame Test		(43.1)					

Table 5.2 Continued on Next Page

Table 5.2 Continued

Type-letter designation	THW-2	THHW	THWN-2	THHN	Insulated conductors without a nylon jacket for Type ACTHH, NM-B, and NMC-B cables	Insulated conductors without a nylon jacket for Type UF-B cable
Vertical-Tray Flame Test	(44.1 and 44.2)				None	
Tray-Cables Sunlight-Resistance Test	(45.1 and 45.2)				None	
Sunlight-Resistance Test for messenger use	(45.1 and 45.2)			Messenger use not applicable		
Oil-resistant wires	(46.1 and 46.2)				None	
Gasoline-resistant and Oil-resistant wires	None	(47.1)		None		
Abrasion Test	None		(49.1)		None	
Crushing Test	None		(50.1)		None	
Impact Test	None		(51.1)		None	
Color coating	(52.1)					
Markings	(53.1 – 72.1)					
^a See 5.2.						
^b Type THHN and THWN-2 wires are required to have over the insulation a jacket of nylon whose minimum thickness at any point is as specified in Table 15.5 (see also 14.1).						
^c The physical properties requirements for individual materials are in UL 1581. See 40.2, 47.1, and index Table 47.1 of UL 1581.						
^d Type THHN and THWN-2 wires, and insulated conductors for Type ACTHH, NM-B, and NMC-B shall employ insulation of PVC or a thermoplastic material other than PVC. See 23.1.						

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Table 5.3
Index to requirements for switchboard and other wires^a

Table 5.3 revised September 9, 1999

Type-letter designation	TBS	FEP	FEPB	PFA	TFE	PFAH	Z	ZW
Maximum temperature	90°C (194°F) dry	90°C (194°F) dry ^b			250°C (482°F) dry		90°C (194°F) dry ^d	90°C (194°F) dry ^d 75°C (161°F) wet
Conductor size	14 – 4/0 AWG (7.1)	14 – 2 AWG (7.1)	14 – 2 AWG (7.1)	14 – 4/0 AWG (7.1)				14 – 2 AWG (7.1)
Conductor metal	Soft-annealed copper for Nos. 14 and 13 AWG Aluminum, copper-clad aluminum, or soft-annealed copper for other sizes (6.3)	Soft-annealed copper (6.1)			Nickel-coated copper or nickel-base alloy (6.2)		Soft-annealed copper (6.1)	
Conductor dimensions	Diameter and cross-sectional area (8.1 and 8.2)							
Conductor – general	Metal coating (9.1 and 9.2)		Splices (11.1 and 11.2)			Separator (10.1 and 10.2)		
Conductor resistance	(12.1)							
Conductor stranding	(13.1 – 13.6)							
Insulation – material	PVC	FEP		PFA	PTFE	PFA	ETFE	
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) Cotton braid (19.1) Glass or Aramid braid (20.1) Saturation and coating of braids (21.1)	None	General (17.1) Glass or Aramid braid (20.1) Saturation and coating of braids (21.1)	None				

Table 5.3 Continued on Next Page

Table 5.3 Continued

Type-letter designation	TBS	FEP	FEPB	PFA	TFE	PFAH	Z	ZW
Assemblies that include single-conductor thermoplastic-insulated wires	None	(24.1)						
Physical properties of insulation ^c	PVC	FEP		PFA	PTFE	PFA	ETFE	
Dielectric voltage-withstand	(28.1.1 and 28.2.1)	(27.1 and 27.2)						
Leakage resistance	(29.1)	None						
Insulation resistance (short-time)	None	(30.1)						
Insulation resistance (temperature factor)	None	(30.2)						
Alternative spark testing	(35.1)	(34.1)						
Insulation resistance in water at rated temperature	None							(33.1.1 – 33.3.2)
Continuity	[pars. 900.13 – 900.17 of UL 1581]							
Room-temperature flexibility	(37.1)							
Heat shock	(38.1)	None						
Cold bend	(39.1 and 39.2)							
Deformation	(40.1)			None				
VW-1 Flame Test	(41.1)							
Horizontal Flame Test	(42.1)							
Vertical Flame Test	(43.1)							
Color coating	(52.1)							
Markings	(53.1 – 72.1)							
^a See 5.2.								
^b The temperature limit is 90°C (194°F) for general use and 200°C (392°F) for special applications, except that a limit of 150°C (302°F) applies for special applications where Nos. 27 – 36 AWG (14.2 – 5.0 mils) strands are used without an individual protective metal coating.								
^c The physical properties requirements for individual materials are in UL 1581. See 40.2, 47.1, and index Table 47.1 of UL 1581.								
^d The temperature limit is 90°C (194°F) for general use and 150°C (302°F) for special applications.								

CONDUCTOR(S)

6 Metal

6.1 Types FEP, FEPB, PFA, Z, and ZW

6.1.1 The conductor wires shall be of soft-annealed copper complying with ASTM B 3-95. 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 298-94, or a coating of another metal or alloy (evaluation required – lead, tin/lead, and tin coatings are not to be used). Size 27 – 36 AWG (14.2 – 5.0 mils or 0.36 – 0.127 mm) strands that are uncoated or have a coating of tin complying with ASTM B 33-94 or a tin/lead coating complying with ASTM B 189-95 are appropriate for use in wire rated for 150°C (302°F). 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 appropriate for use in wire rated for 200°C (392°F).

6.1.1 revised November 1, 2001

6.2 Types TFE and PFAH

6.2.1 The conductor shall be of nickel-base alloy complying with ASTM B 160-93 and having a tensile strength of 65,000 ±15,000 lbf/in² or 448 ±103 MN/m² or 44,816 ±10,342 N/cm² or 45.7 ±10.5 kgf/mm², an elongation of at least 35 percent, and a nominal volume resistivity of 66 ohm·cmil/ft at 20°C (68°F) or 0.110 ohm·m²/m at 20°C (68°F) or shall be of soft-annealed copper complying with ASTM B 3-95. A solid copper conductor and each strand in a stranded copper conductor shall be protected against oxidation by a coating of nickel complying with ASTM B 355-95.

6.2.1 revised November 1, 2001

6.3 Types TW, THW, THWN, THHN, and TBS and insulated conductors for armored cable Types ACHT and ACTHH and for cable Types UF-B, NM-B, and NMC-B

6.3.1 The conductor shall be of soft-annealed copper, copper-clad aluminum, or an aluminum alloy. Soft-annealed copper shall comply with ASTM B 3-95. A metal coating that is provided on soft-annealed copper or on copper-clad aluminum in compliance with Metal Coating, Section 9, shall be of tin complying with ASTM B 33-94, 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 298-94, or of another metal or alloy (evaluation required). 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.

6.3.1 revised November 1, 2001

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.

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Table 7.1
Conductors

Table 7.1 revised September 29, 1998

Wire type	Sizes (see Tables 5.1 and 5.2) and metal	Temper	Assembly
THW-2, THWN-2, THHW, TW, THW, THWN, THHN, TBS and Insulated Conductors for Type ACTH, ACTHH, UF-B, NM-B, and NMC-B cables	14 – 4/0 AWG copper	Soft-annealed	Solid
	2 – 4/0 AWG copper	Soft-annealed	Compact-stranding ^{a,d}
	14 AWG – 2000 kcmil copper	Soft-annealed	Compressed stranding and every other type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
	12 – 8 AWG aluminum	b	Solid
	7 – 4/0 AWG aluminum	Semi-annealed ^c	Solid
	12 AWG – 2000 kcmil aluminum	Semi-annealed ^c	Compressed stranding and every other type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
	12 AWG – 1000 kcmil aluminum	Semi-annealed ^a	Compact-stranding ^a
	12 – 4/0 AWG copper-clad aluminum	c	Solid
	12 AWG – 2000 kcmil copper-clad aluminum	c	Any type of stranding ^a covered in Table 210.2 of UL 1581 other than compact and compressed stranding
TFE and PFAH	14 – 4/0 AWG copper	Soft-annealed	Solid or any type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
	14 – 4/0 AWG nickel-base alloy	See 6.2.1	
FEP and ZW	14 – 2 AWG copper	Soft-annealed	Solid or any type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
FEPB	14 – 2 AWG copper	Soft-annealed	Solid or any type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
PFA and Z	14 – 4/0 AWG copper	Soft-annealed	Solid or any type of stranding ^a covered in Table 210.2 of UL 1581 other than compact stranding
^a See 13.1 – 13.6. ^b Aluminum-wire stock (aluminum-alloy conductor material). ^c See 6.3.1. ^d See 71.1.			